

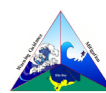
Clallam County's



# ***Tsunami Train the Trainer Guidebook***



This Washington State Emergency Management Division educational project was developed in partnership with the NOAA Pacific Marine Environmental Laboratory, SeismicReady Consulting, Inc., and the National Tsunami Hazard Mitigation Program



# Clallam County ***Train-the-Trainer***

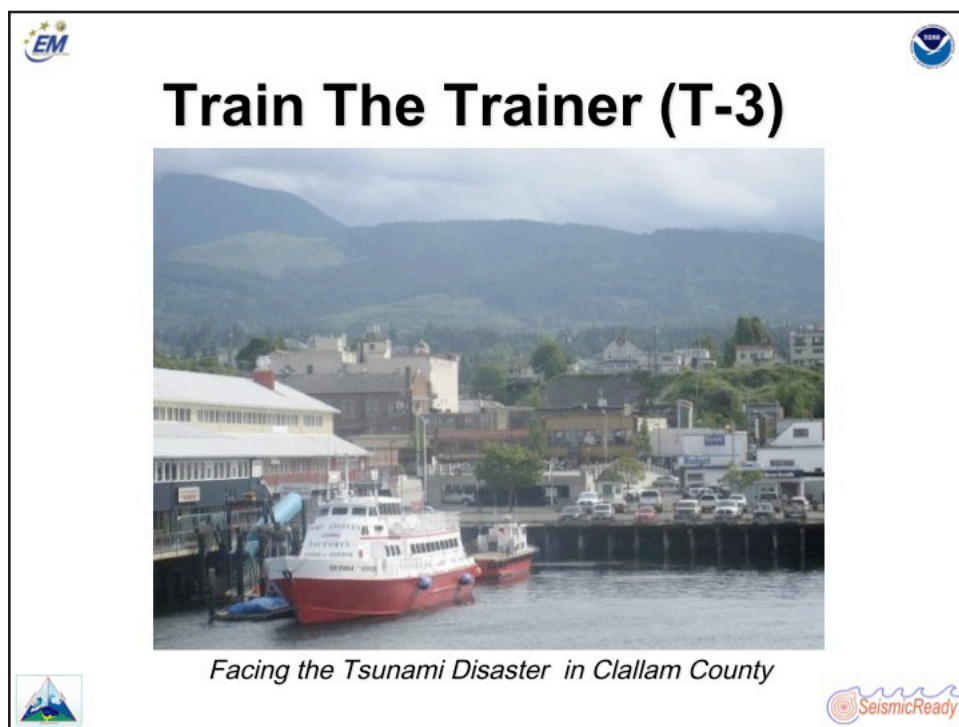
## **Introduction**



### **Course Introduction:**

Clallam County is vulnerable to both distant tsunamis (such as the 1964 Alaska Earthquake and Tsunami) and local tsunamis (1700 Cascadia Subduction Zone Earthquake and Tsunami). This course provides participants with an understanding of the tsunami hazard, current hazard assessment tools and products, tsunami warning and dissemination systems, effective public response and potential challenges in educating the public.

Public education is a critical component of the preparedness process and with the participants help, Clallam County Emergency Management can provide people with the knowledge and tools they need to make the right choices when a tsunami strikes their community.





**Slide 1.**

### **Slide Learning Objective:**

-Summarize the briefing content and outcome of briefing.

Photo: Port Angeles, WA. Due to geographic isolation, the Clallam County Emergency Management has a 90 minute class that helps organize neighborhoods to respond in the first hour of a disaster when lives can be saved by quick action. Since this program was launched in June of 2007, more than 700 citizens have been trained and know what to do immediately to assist their neighbors.







## Welcome

- **Welcome/introduction from instructors**
- **Class structure/housekeeping**
  - Breaks
  - Lunch
  - Restrooms
  - Emergency exits
  - Silence cell phones

*...and for an Earthquake what should we do?*



Slide 2. Welcome


### Slide Learning Objectives:

- Welcome the participants and introduce instructors and WAEMD personnel. Let them know this is an WAEMD and NOAA/PMEL partnership.
- Explain breaks and lunch, where the restrooms are and emergency exists
- As participants to please silence cell phones during the course
- Class structure will be lecture with discussion after each briefing --- approximately 15 minutes will be allow for discussion. Participants should write down questions that can be discussed during breaks. If they have a question please raise your hand
- There will be two 15 minute breaks (one morning and one afternoon) and one hour for lunch).
- Explain where restrooms, emergency exits are
- Ask them please turn off cell phones or put them on vibrate


### Stress:

Washington is number 2 for earthquake risk in the US and in case of an earthquake to please “drop, cover, and hold”. If the course is being taught in a tsunami hazard zone, they need to wait for the ground shaking to stop and make sure it is safe to leave the area and head to high ground.







## Introductions



- **Name**
- **Agency**
- **Background**
- **Experience**
- **What you hope to get out of the course**



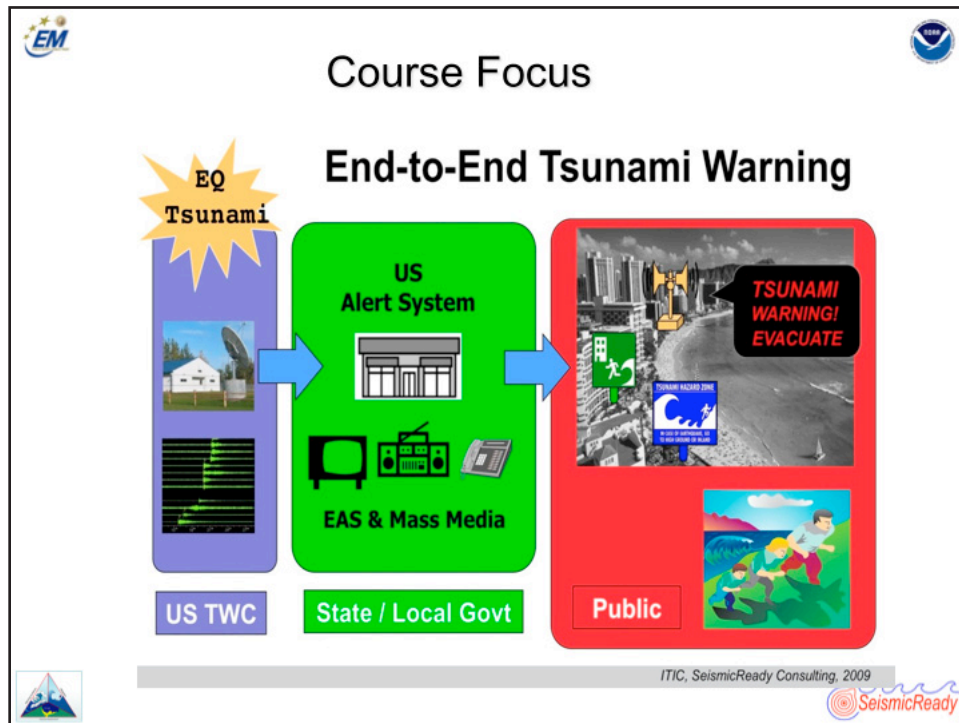
**Slide 3. Introduction**

**Slide Learning Objectives:**

The participants should take turns and introduce themselves. In their introductions, participants and instructors should include the following information:

- Name
- Agency
- Background
- Experience
- What they hope to get out of the course

Clallam County  
**Train-the-Trainer**  
Introduction



Slide 4. Course Focus

**Slide Learning Objectives:**

Provide the participant with basic knowledge of the End-to-End Tsunami System that will allow them to provide tsunami awareness public education to the public.

**Stress:**

In recent years new shorthand terminology has been used to describe the entire process required to detect, warn, and elicit protection measures for a natural hazard. Increasingly this comprehensive process is referred to as End-to-End, meaning from the initial to the final steps required for a successful system. The term End-to-End does not always translate accurately, and some cultures prefer to refer to the process as beginning to end. This course is geared to only discuss what the public needs to know about tsunamis, what to expect, and response actions they will need to take. Tsunami resiliency requires a community to assess all possible lines of defense, from warning systems to evacuation routes to land use planning. No single solution exists.

The ITIC and the former Washington State Tsunami and Earthquake Program Manager collaborated to provide the following summary on End-to-End Warning.

**END-TO-END TSUNAMI WARNING SYSTEM – AN OVERVIEW**

*UNESCO/IOC – NOAA International Tsunami Information Center (ITIC)*

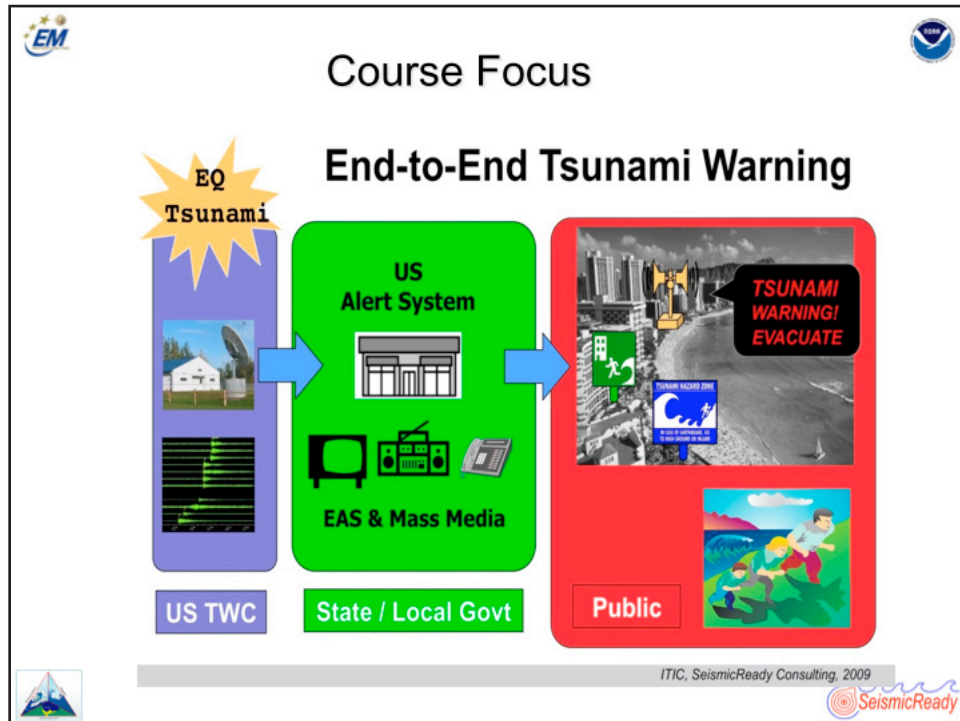
*SeismicReady Consulting (George Crawford)*

*December 2009*

The overview summarizes end-to-end tsunami warning. In time, it covers activities for event monitoring and warning, alert dissemination, emergency response, and public

# Clallam County **Train-the-Trainer**

## Introduction



Slide 4. Course Focus



**(continued)**

action. An effective tsunami warning system is achieved when all people in vulnerable-coastal communities are prepared to respond appropriately and in a timely manner upon recognizing that a potential destructive tsunami may be approaching. Meeting this challenge requires round the-clock monitoring with real-time data streams and rapid alerting, as well as prepared communities, a strong emergency management system, and close and effective cooperation and coordination between all stakeholders.

To warn without preparing, and further, to warn without providing a public safety message that is understandable to every person about what to do and where to go, is clearly useless. While alerts are the technical trigger for warning, any system will ultimately be judged by its ability to save lives, and by whether people move out of harm's way before a big tsunami hits.



End-to-end tsunami warning involves a number of stakeholders who must be able to work in coordination and with good understanding of each others' roles, responsibilities, authorities, and action during a tsunami event. Planning and preparedness, and practicing in advance of the real event, helps to familiarize agencies and their staff with the steps and decision-making that need to be carried out without hesitation in a real emergency. Tsunami resilience is built upon a community's preparedness in tsunami knowledge, planning, warning, and awareness.





## Course Outline

- The community's hazard
- How to reduce risk
- How to respond to a tsunami
- Group Discussion
  - Challenges in Community Workshops
- Course Evaluation



Slide 5. Course Outline

### Slide Learning Objectives:

Summarize each topic

#### Stress:

##### *The community's hazard*

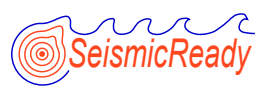
The community's hazard includes several components. We'll introduce what is a far-field and near-field tsunami. Participants will learn about scientific tools such as tsunami modeling and inundation maps that help at-risk communities understand their risk and exposure to better prepare for a tsunami hazard.



##### *How to reduce risk*

The participants now have an understanding of the tsunami hazard and hazard mitigation tools available for identifying tsunami vulnerability and exposure in the community. Topics such as understanding community vulnerability, evacuation, the importance of organizational, neighborhood and personal preparedness, and TsunamiReady Program provide participants with a basic understanding of what communities can do to support tsunami preparedness.

##### *How to respond to a tsunami*

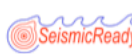

This briefing describes the difference between a local and distant response, describes the alert messages released by tsunami warning centers to warn all levels of government down to the "last mile" including evacuation/all-clear messaging; communication systems in the community, and how to improve effective public response.





## Course Outline

- The community's hazard
- How to reduce risk
- How to respond to a tsunami
- Group Discussion
  - Challenges in Community Workshops
- Course Evaluation



Slide 5. Course Outline

**(continued)**

*Group Discussion – Challenges in Community Workshops*


As a group, participants will discuss pre-workshop meetings with community leaders to identify current tsunami preparedness efforts and how to customize a public education forum to increase awareness and preparedness. Participants will have the opportunity to ask questions and share their experiences in holding public forum in their community.

*Wrap-up (Course evaluation)*


Participants will be given a short course evaluation to assess the effectiveness of the course and suggested topics/improvements.

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Introduction

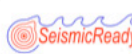





## Public Education Saves Lives



*Thank You for helping making a difference!*



Slide 6. Public Education Saves Lives

**Slide Learning Objectives:**

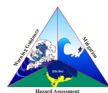
Describe the importance of public education

**Stress:**

Clallam County's coastal communities are at risk from a Cascadia Subduction Zone Earthquake - more lives will be saved through tsunami education than through man-made warnings. A tsunami generated off our coast will arrive in 30 minutes or less, with maximum force, on shores where people will be contending with major damage from the earthquake. The waves will reach shore before they register clearly at the nearest buoy, and they will also reach people on the beach or low lying areas sooner than a warning center's message.

Tsunami education offers the main hope for helping such people recognize natural cues to evacuate themselves, as illustrated in the 2009 America Samoa Tsunami. The mayor of Amenave in American Samoa had attended a workshop for village mayors on tsunami hazards. When he felt the earthquake, he grabbed his bullhorn and ran through the village notifying people to evacuate - NO LIVES WERE LOST through his actions. With your help, Clallam County can reduce the lost of life from our next local tsunami.

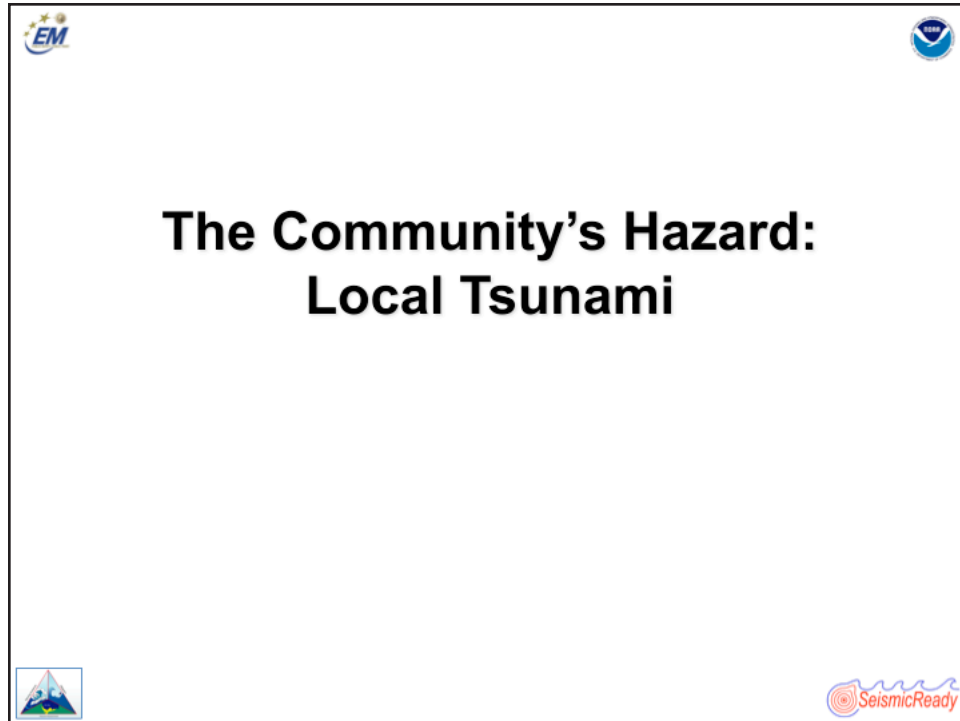
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Notes



Notes

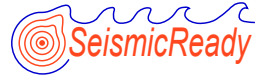
***End of Section***



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Local Tsunami



Slide 1.

**Slide Learning Objective:**  
Introduce the Local Tsunami topic.







## Outline

**Type of hazard**

- Local tsunami

**Evidence of hazard**

- Past events



**Slide 2. Outline**

**Slide Learning Objectives:**

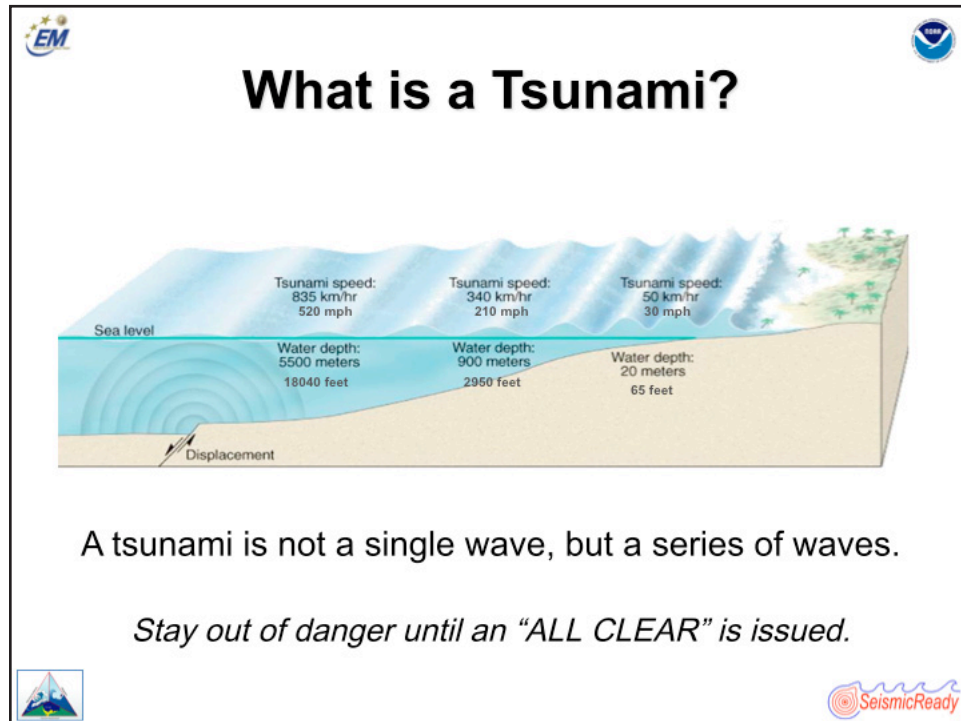
We will discuss Washington's threat from a local tsunami.

**Stress:**

You will learn:

- Where a local tsunami can be generated
- How it is generated and
- Evidence that local tsunamis can cause damage to Washington's coastal communities, including Clallam County.

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Local Tsunami



Slide 3. What is a Tsunami?

**Slide Learning Objectives:**

Learn a tsunami's basic characteristic.

**Stress:**

*What is a tsunami?*

Tsunamis are a series of long period waves generated by large scale movement of a portion of the water. The period refers to the time it takes for two successive wave crests to pass a point. (A wind wave has a period of about ~20 seconds, while a tsunami wave can be minutes or even an hour). In the image above, the large scale movement of water is triggered by an earthquake that causes significant seafloor deformation.

*Tsunami wave characteristics:*

A tsunami is not one wave, but a series of waves. The time between successive wave crests is usually tens of minutes apart and continues arriving for many hours. The first wave is almost never the largest. For instance, in a modeled Cascadia Subduction Zone event the first and largest wave arrives at Port Angeles within 2 hours (~9 feet). However, the same modeled event shows the first wave arriving at Neah Bay within 30 minutes, but the largest wave (~10 feet) being the second arriving within 1 hour .

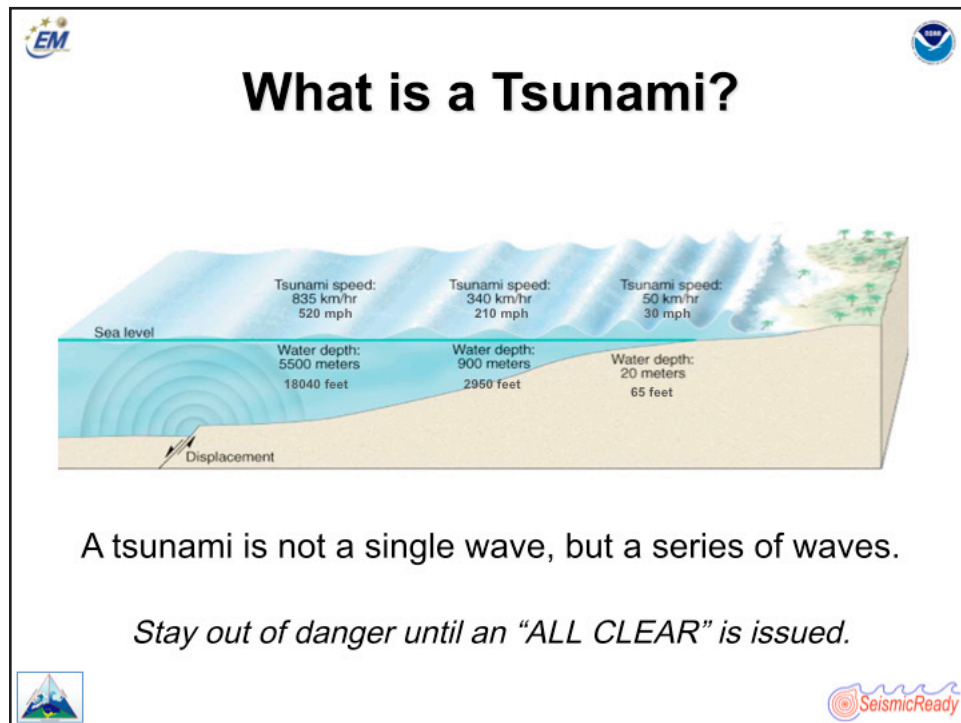
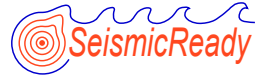
**Waves in open ocean**

Speed: 300 to 700 mph  
Wave Length: normally over 90 miles  
Wave Height: up to 3 feet  
Other: waves too small to be observed

**Waves in shallow water**

Speed: as low as 30 mph  
Wave Length: diminished from open ocean  
Wave Height: up to 100 feet

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**Slide 3. What is a Tsunami?**

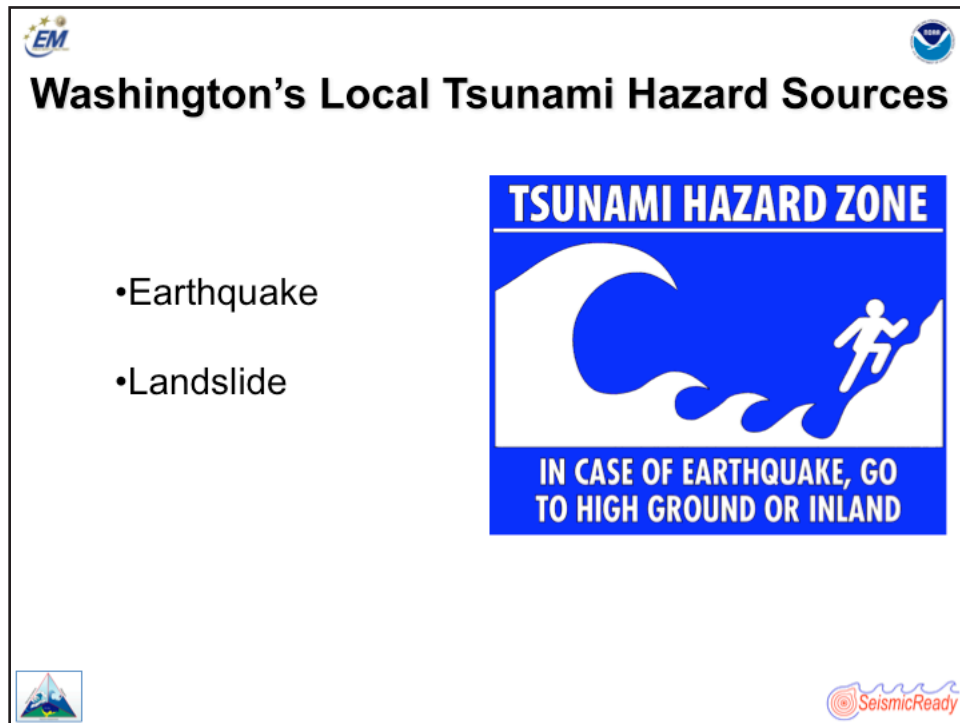
**(continued)**

*As tsunami waves approach shore from open ocean:* wave energy is transferred from wave speed to wave height

*Note:*

- Wave length refers to distance measured from crest to crest. Wind waves have wave-lengths of several hundred meters, while tsunami waves have wave lengths of many tens of miles.
- Wave height refers to distance measured from trough to crest.

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Local Tsunami



Slide 4. Washington's Local Tsunami Hazard Sources

**Slide Learning Objectives:**

Understanding different tsunami causes and those most relevant to Washington, specifically Clallam County.

**Stress:**

*Why is understanding tsunami science important?*

Tsunami science serves as a cornerstone to mitigation planning activities. The identification of a tsunami risk highlights the need for tsunami-related projects.

*What causes a tsunami?*

In Washington, earthquake and landslides are the most probable causes. Below you can find information about all tsunami sources.

Subduction zone/fault earthquake

Global Frequency: most common cause of tsunami; several per year

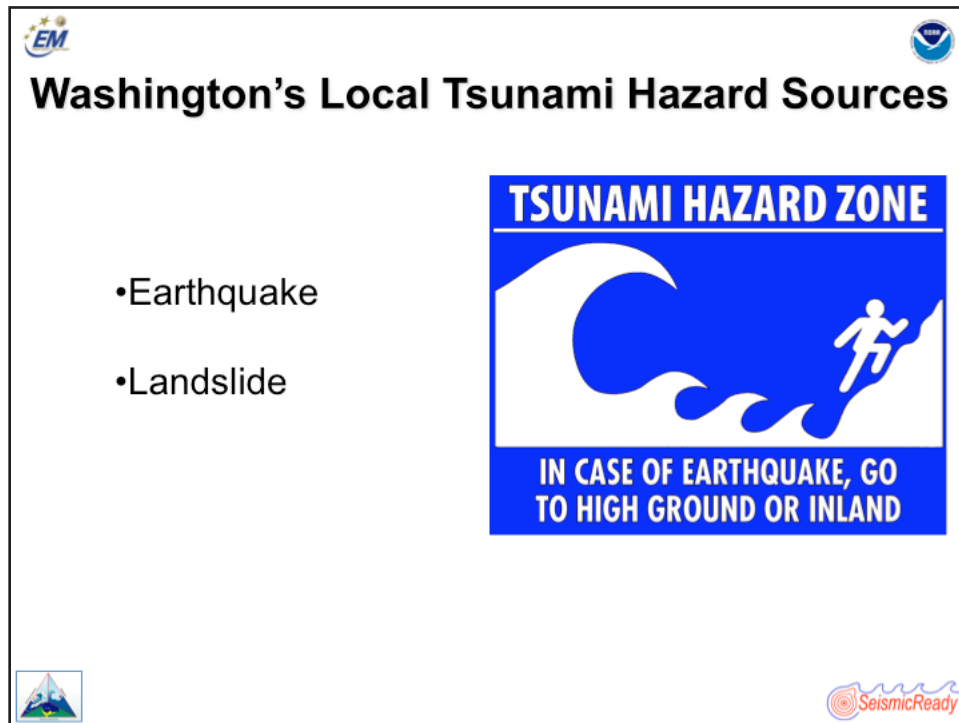
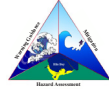
Tsunami Category: distant (normally) Example: Sumatra Island, Indonesia, (2004) or Cascadia Subduction Zone (1700)

Volcanic eruption

Global Frequency: low

Tsunami Category: local (normally) Example: Krakatua, Indonesia (1883)

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Slide 4. Washington's Local Tsunami Hazard Sources

**(continued)**

Coastal landslides, rockfalls, or slumps

Global Frequency: moderate

Tsunami Category: local (normally) Example: Lituya Bay, Alaska, (1958)

Meteor/Asteroid

Global Frequency: very low

Tsunami Category: distant (dependent on mass)

Example: Brazos River, Texas

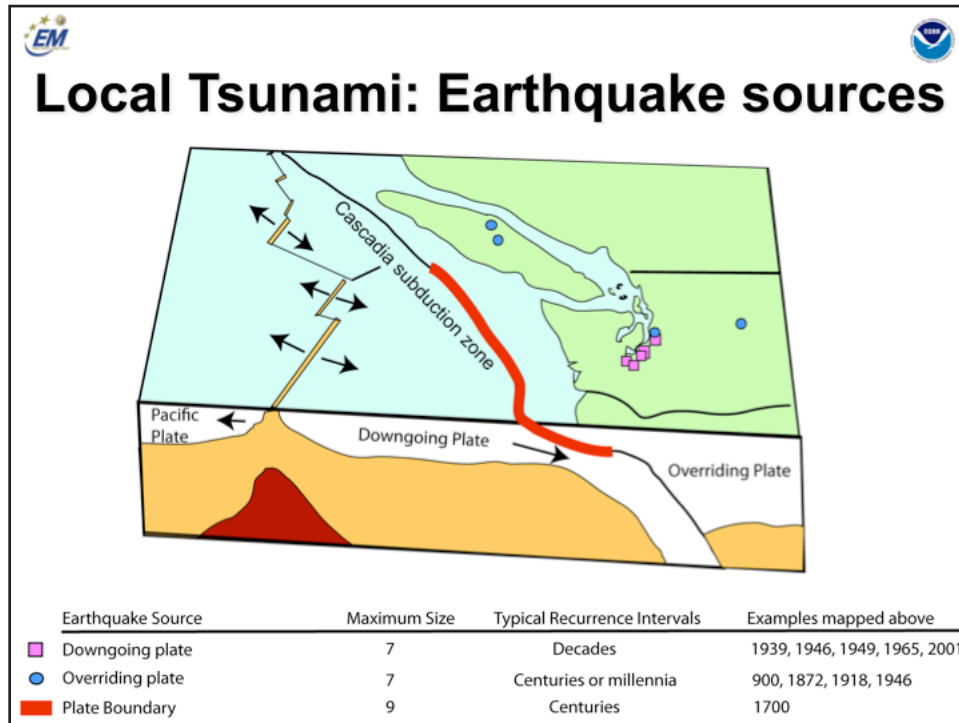
*Tsunami categories*

Local: tsunami generating event occurs at or near the coast of a community. The first waves may reach coastal community within minutes/seconds after the ground shaking. (Example: 1700 Cascadia Subduction Zone, see slides 6-11 for more information).

Regional: the most common tsunami. These events occur within a few minutes to a couple of hours after the generating event. Coastal communities affected by the event may not feel the tsunamigenic earthquake. (Example: 2005 CA Earthquake/Tsunami generated a Tsunami Warning for Washington coast)

Distant: very large tsunamigenic earthquakes may cause tsunamis which could impact distant coastal communities. The first waves could reach a coastline many hours after the earthquake occurs. (Example: Chile Feb 27 2010. First wave arrived in Port Angeles after 17 hours 20 minutes. The maximum wave measured at Port Angeles was just over half a foot above sea level. At La Push, first wave arrived after 16 hours and 20 minutes. The maximum wave measured at La Push was just under 9 inches above sea level)

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 Local Tsunami



Slide 5. Earthquake Sources

**Slide Learning Objectives:**

Learn the different type of earthquake sources in Washington and their history of generating tsunamis.

**Stress:**

Washington is # 2 in the nation for earthquake risk.

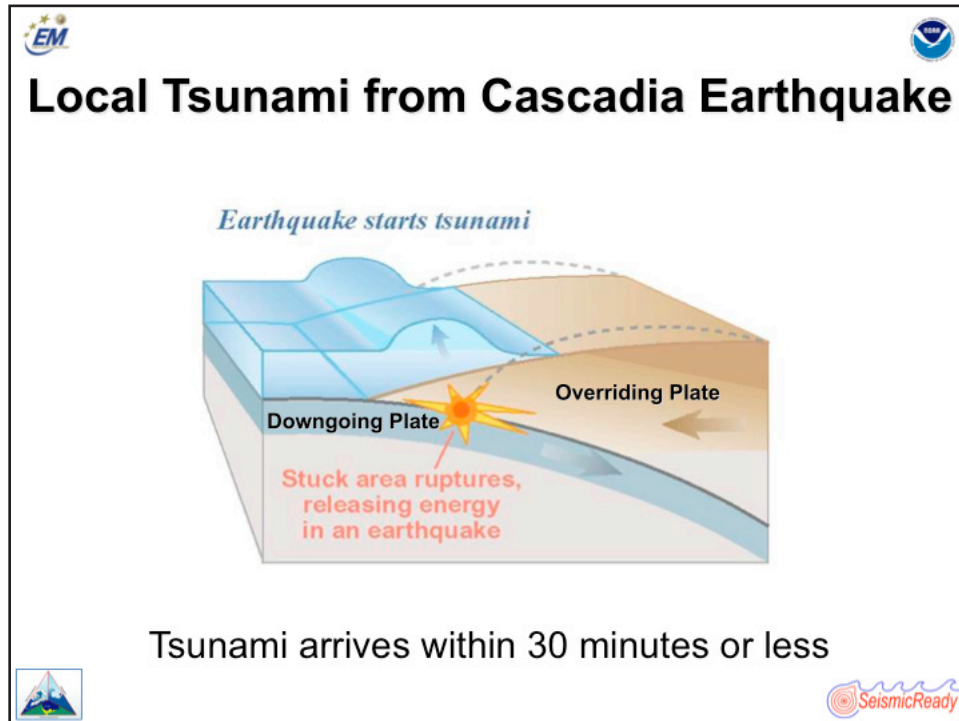
*Examples*

Downgoing plate: 1949 Olympia earthquake Mw 7.1 - a few days after the earthquake a landslide generated a tsunami in the Tacoma Narrows. Downgoing earthquakes are generally too deep to cause a tsunami.

Overriding plate: 1946 Vancouver Island earthquake generated a local tsunami but did not impact Washington. The Mw 7.3 earthquake was felt as far south as Olympia and Tacoma. Overriding earthquakes are generally too deep to cause a tsunami.

Subduction zone: 1700 Cascadia Subduction Zone Mw 9.0.

Generally, a Mw 7.0 and higher earthquake is required to generate a tsunami. However, extreme cases exists were smaller earthquakes have caused landslides which have generated tsunamis.



Slide 6. Cascadia Earthquake

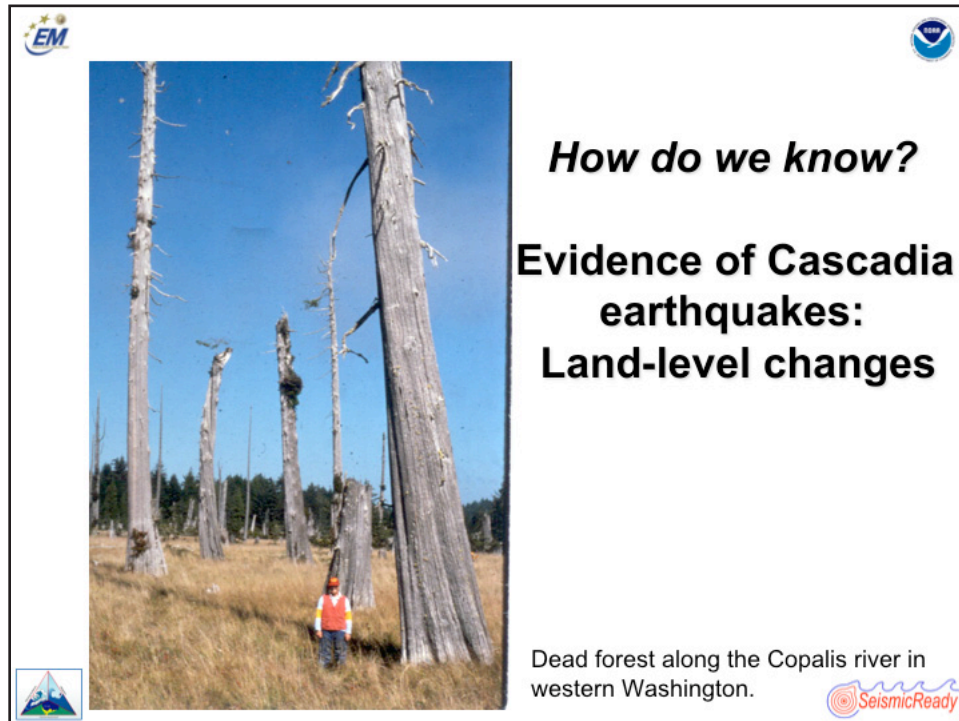
**Slide Learning Objectives:**

Learn how the subduction process can generate a local tsunami impacting Clallam County.

**Stress:**

1. The Juan de Fuca plate descends beneath the North America, this process is known as subduction
2. Accumulated energy raises the seafloor (and the water above it) and a tsunami can be created
3. The initial tsunami wave will arrive in Clallam County within 30 minutes or less

Subduction zone earthquakes are different because the fault is much bigger and there is much more movement along it. Overriding earthquakes are smaller versions of subduction earthquakes, but they aren't as long and don't have as much movement. Meanwhile, Downgoing plate earthquakes are due to a change in mineralogy of the plate as the heat and pressure rise.



Slide 7. Evidence of Cascadia Subduction Zone tsunami

**Slide Learning Objectives:**

Understand the evidence that reveals the strength of a Cascadia Subduction Zone earthquake and tsunami.

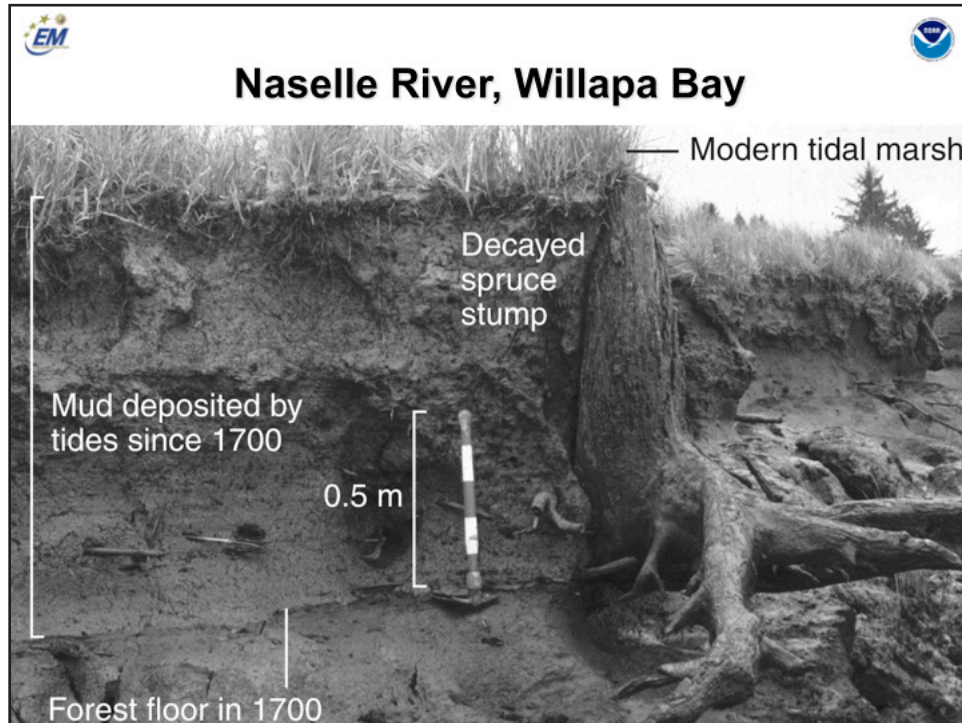
**Stress:**

*How do we know when the last Cascadia Subduction Zone earthquake occurred? And that it produced a tsunami?*

"The answer is blowing in the wind". The wind along the Washington coast. This is a picture of a dead forest along the Copalis river, about a mile or so from the Highway 109 bridge. The dead trees in this picture are western red cedars, and as you probably know, are very resistant to rot once they die. How did these trees die?

They were killed by salt water. During the 1700 earthquake, imagine these trees covered with thick, green branches. Then, during the earthquake, the marsh along the Copalis river suddenly drops, and salt water rushes in. The trees slowly die from the salt water, and as the river is still flows, it slowly begins to rebuild the marsh. But the trees finally die. Some 300 years later, a paleoseismologist matches the tree rings of a dead tree and compares it to some of the long-lived cedar trees along the coast. That match tells the paleoseismologist that the tree died during the winter of 1699-1700. This is the evidence that a significant Cascadia Subduction Zone earthquake occurred about 1700.

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Local Tsunami



Slide 8. Evidence of Cascadia Subduction Zone tsunami

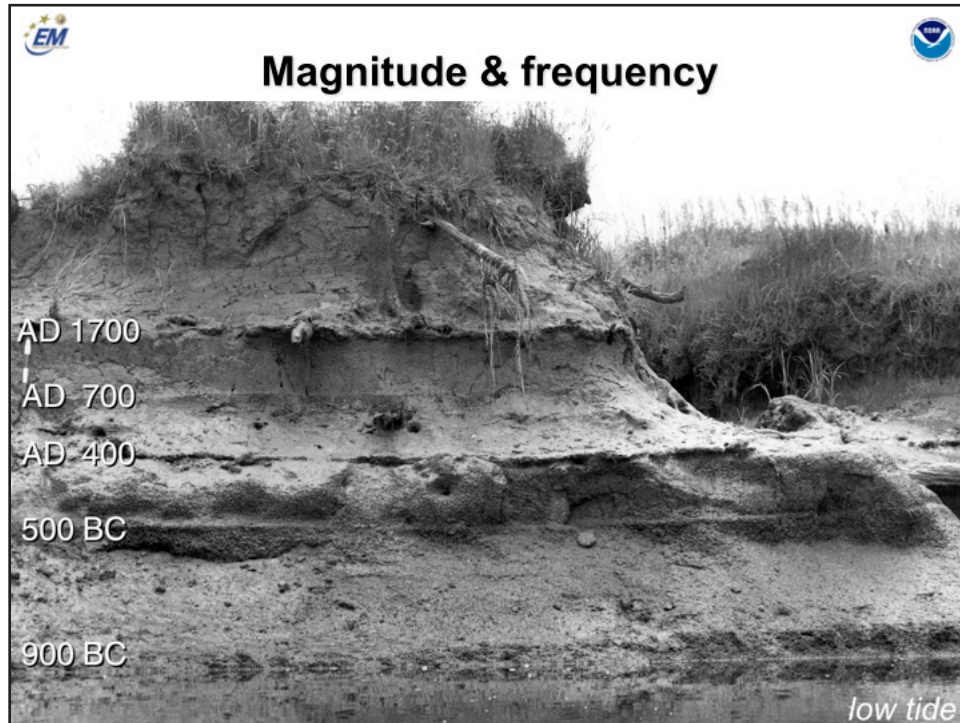
**Slide Learning Objectives:**

Understand the evidence that reveals the strength of a Cascadia Subduction Zone earthquake and tsunami.

**Stress:**

Here (photo in slide) is what we find on our coast, more evidence that a significant Cascadia Subduction Zone earthquake occurred about 1700. This is from the Naselle river which flows into Willapa Bay. You can see the decayed spruce stump, the old forest floor in 1700, and the thick sequence of mud deposited since 1700.

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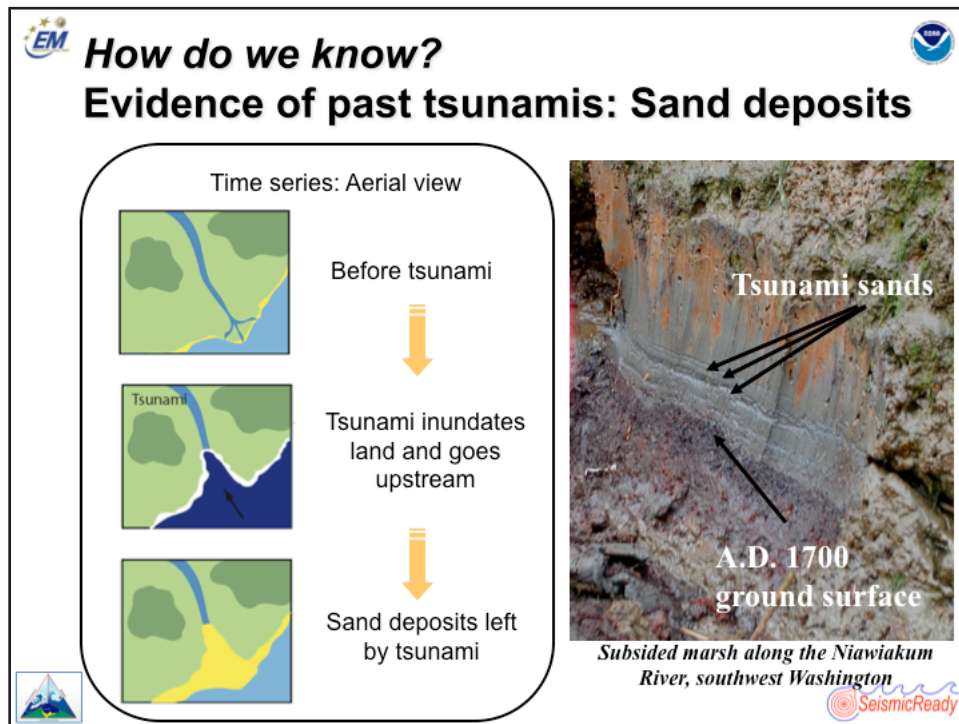
Slide 9. Evidence of Cascadia Subduction Zone tsunامي

**Slide Learning Objectives:**

Understand the evidence that reveals the strength of a Cascadia Subduction Zone earthquake and tsunami.

**Stress:**

It's only a matter of time. On the Johns river, you can see 5 such soil layers and still find roots in growth position for some of the older events. Will the next event be in 2200?



Slide 10. Evidence of Cascadia Subduction Zone tsunami

### Slide Learning Objectives:

Understand how tsunami deposits reveal the strength of a Cascadia Subduction Zone earthquake and tsunami.

### Stress:

The previous slides gave us evidence of a Cascadia Subduction Zone earthquake in our region but what about the tsunami? Again, its from the geology. Tsunamis pick up very distinctive sands (sometimes the minerals are different or there are marine microfossils like foraminifera or diatoms - like plankton) as they form, and they deposit those on the beaches as they wash over the landscape.


Similar to the killing and burial of the Copalis River trees, tideflat mud covers and buried tsunami sands. (At Niawaikum the bottom is forest peat, then tsunami sand, then marine mud)

Sedimentary tsunami deposits allow geologists to expand the record of tsunamis, improving hazard assessment. Frequency and magnitude, two primary factors in tsunami hazard assessment, can be assessed through tsunami deposits. Where more than one tsunami deposit is preserved, the possibility is presented to determine tsunami recurrence.


The tsunami deposit can tell the minimum distance inland and run up as well as the minimum current needed to move the sediment. So it helps us understand the range of current strength and inundation.


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## Oral History & Written Records





Time keeping by the Japanese allows confident knowledge regarding the size and time of the 1700 Cascadia Subduction Zone event.

*"Among the signs of danger, the elders warn, is long-lasting shaking moving from west to east, and sand that becomes so loose people walking on the beach sink into it – Elders tell the young they must run to high ground"*



Slide 11. Evidence of Cascadia Subduction Zone tsunami

**Slide Learning Objectives:**

Understand how oral and written records reveal the strength of a Cascadia Subduction Zone earthquake and tsunami.

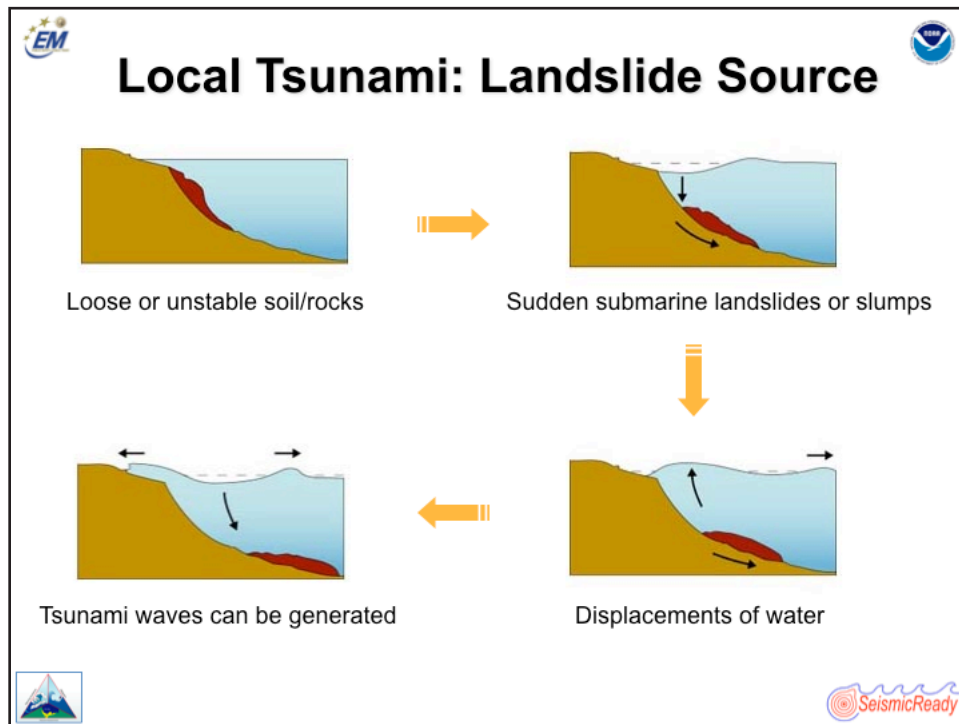
**Stress:**

*Oral History*

- Compliments scientific information
- Passed down to the next generation in the tradition of mythology.
- Oral traditions of Native American tribes of the Washington Coast describe what is interpreted as a huge earthquake and tsunami destroying coastal villages.

*Written Records*

It is the accurate written records from samurai, merchants, and villagers of the tsunami and the accurate time keeping by the Japanese that allows confident knowledge of the size and time of the 1700 Cascadia Subduction Zone event



Slide 12. Landslide Source

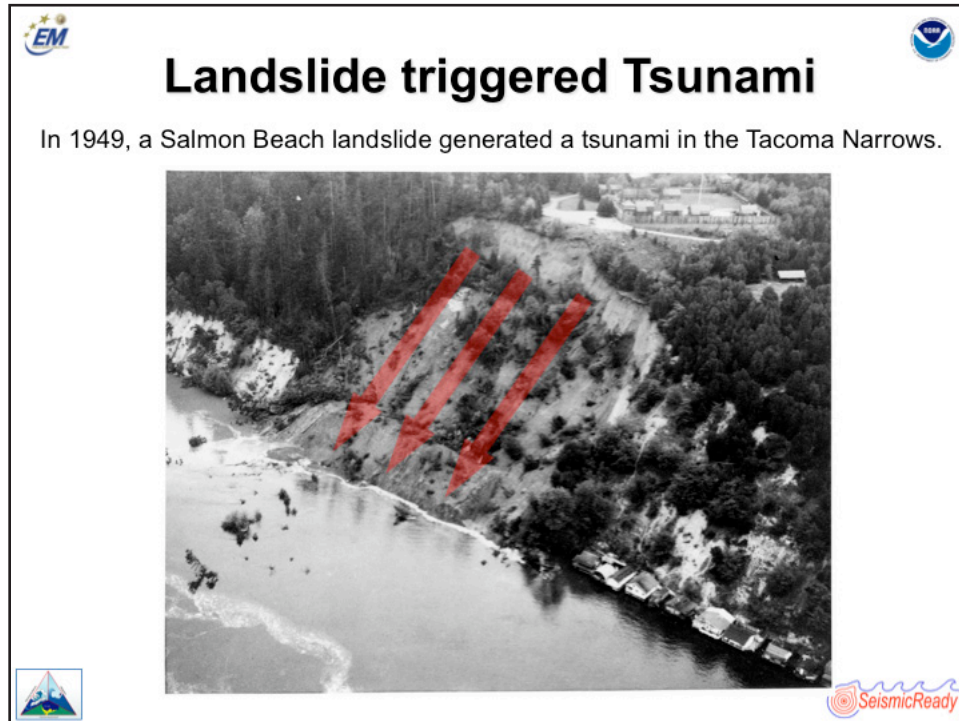
**Slide Learning Objectives:**

Understand how a landslide can generate a tsunami

**Stress:**

Tsunami waves can be generated from displacements of water resulting from rock falls, and sudden submarine landslides or slumps.

Submarine landslides can originate on delta slopes of major rivers.  
(Example: 1894 Puyallup River delta in Commencement Bay)



Slide 13. Landslide Source



**Slide Learning Objectives:**

Understand how a landslide can generate a tsunami in Washington

**Stress:**



Three days after the 1949 Olympia earthquake a landslide generated a tsunami in the Tacoma Narrows. The sliding of a steep bluff in Salmon Beach into Tacoma Narrows (see photo) generated a wave 8 feet high near Point Defiance in 1949. The water receded about 25 feet. The cliff in the image is an estimated 400 feet.





## Local Tsunami: Recap

- Originates from a source close to the site of interest, and arrives within 30 minutes or less. The site of interest might also experience the effects of the triggering event.
- Local earthquakes can generate local tsunamis. Subduction Zone earthquakes are likely to trigger a local tsunami.
- Landslides originating from above or below the water can generate a local tsunami.



Slide 14. Local Tsunami Recap

### Slide Learning Objectives:

Summarize Clallam County's local tsunami scenarios.



### Stress:

A near-source generated tsunami originates from a source near the site of interest and arrives within 30 minutes or less. The Cascadia Subduction Zone is our local source which is off the coast of Washington. Computer models indicate that a Cascadia-generated tsunami could reach nearly 30 feet in height and affect the entire Washington coast. The first wave would reach coastal communities within 30 minutes after the earthquake. Sea and land level changes will be noticed. For a Cascadia event, the ground shaking, which will last for several minutes, is your warning to evacuate to high ground. Follow the evacuation route signs to the assembly area. If you are unable to get to high ground in time, consider vertical evacuation. Remember that for a local event, the evacuation starts with the natural warning and there will be little to no warning time.

For further information seek the following resources:

1. Clallam County Hazard Mitigation Plan
2. Washington State Hazard Mitigation Plan: Hazard Profile – Tsunami
3. Guidelines for Design of Structures for Vertical Evacuation from Tsunamis (FEMA P646)
4. Tsunami Brochures







## Local Tsunami and Response: In Brief

Key points for earthquake source:

- Source is local
- Ground shaking and sea level changes
- Little to no warning
  - Ground shaking is your warning
- Evacuation starts with natural warning

*Further discussion in “Response” training section.*



### Slide 15. Local Tsunami Response

#### Slide Learning Objectives:



Briefly summarize Clallam County’s local tsunami warning and response.  
(Note: In depth discussion in “Response” section)

#### Stress:

*Key points:*



- A major subduction zone earthquake can destroy local infrastructure (ie roads, bridges, buildings, etc). Be sure to protect yourself from the earthquake first.
- Once the ground shaking has stopped head to high ground to evacuate the inundation area.
- An official warning is not likely to arrive by the time the first wave arrives.
- A tsunami can last for hours, do not return to inundation area until authorities have declared the area safe (an “All-clear”).
- Secondary hazards like fires and hazardous material spills in the inundation area could be dangerous even after the tsunami waves have stopped arriving.





## Discussion Question

- What are the local tsunami sources Washington communities face?
- Name the evidence that can support that a community has a tsunami hazard?



### Slide 16. Discussion Questions

#### Slide Learning Objectives:

- Review learning points from presentation.
- Discussion questions for community workshop.

#### Answers:

*Answer question 1:* Earthquakes and landslides are the most probable local tsunami sources.

*Answer question 2:* Geologic evidence and oral histories prove that Cascadia Subduction Zone created a significant tsunami along the WA coast in 1700. Modern records have documented recent events such as the 1949 Olympia earthquake a landslide generated a tsunami in the Tacoma Narrows.

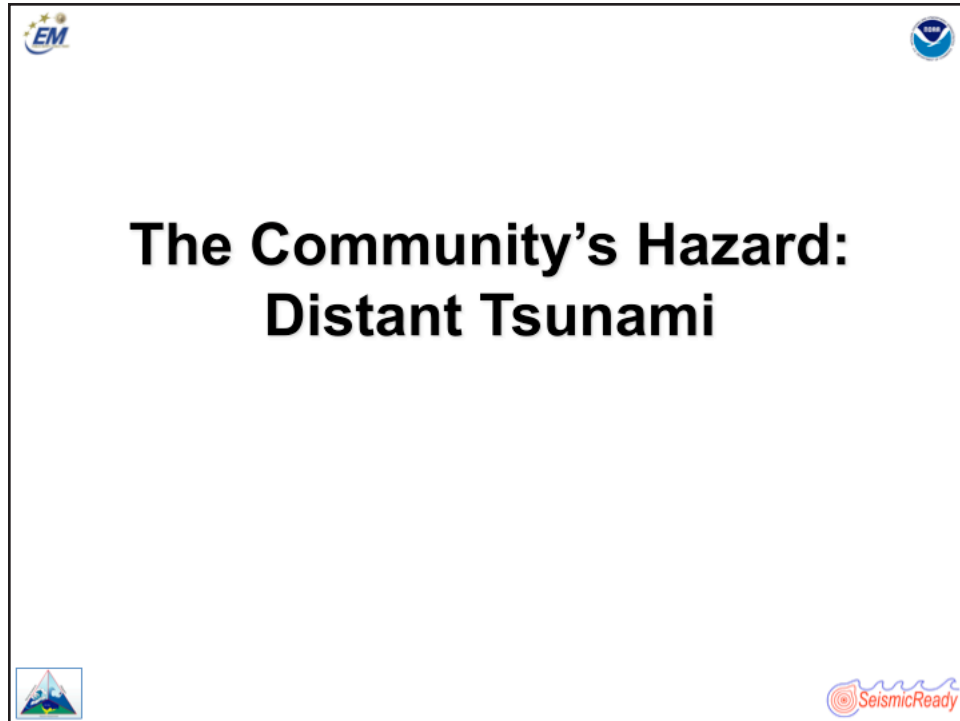
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Notes



Notes

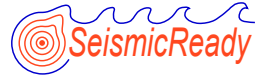
***End of Section***



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**Distant Tsunami**



Slide 1.

**Slide Learning Objective:**  
Introduce the Distant Tsunami topic.







## Outline

**Type of hazard**

- Distant tsunami

**Evidence of hazard**

- Past events



Slide 2. Outline

**Slide Learning Objectives:**

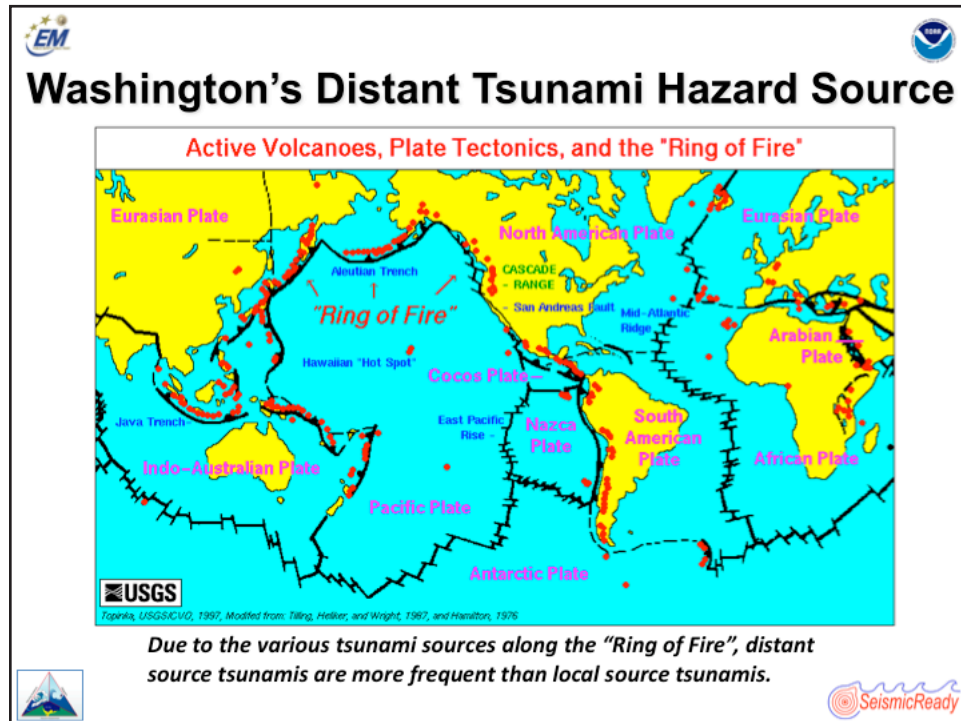
We will discuss Washington's threat from a distant tsunami.

**Stress:**

You will learn:

- Where a distant tsunami can be generated
- How it is generated and
- Evidence that distant tsunamis can cause damage to Washington's coastal communities, including Clallam County.

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Distant Tsunami



Slide 3. Washington's Distant Tsunami Sources

**Slide Learning Objectives:**

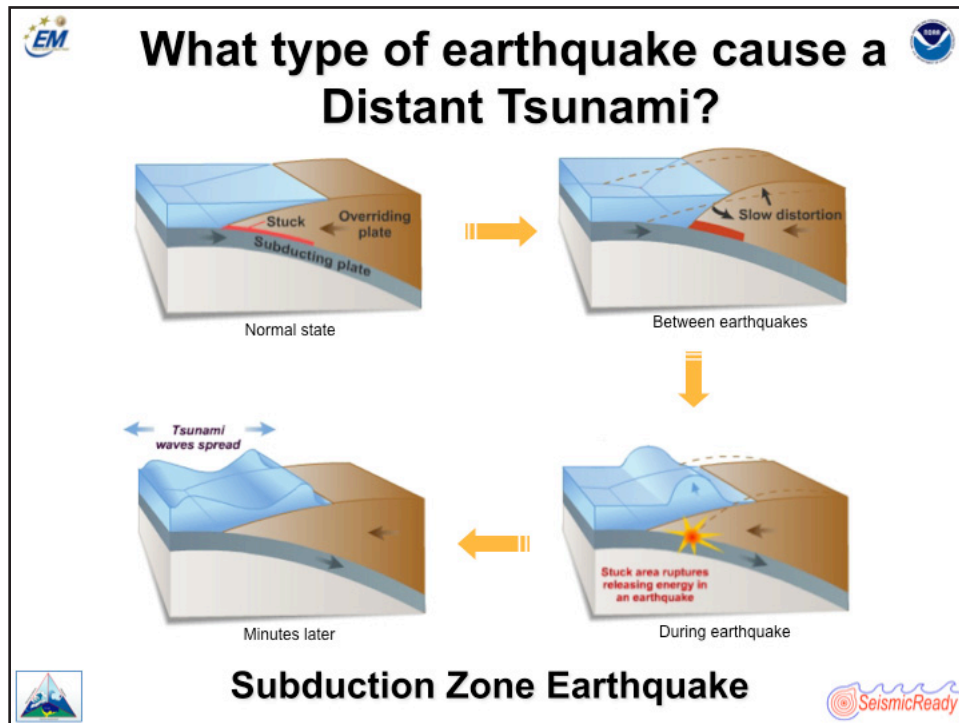
Learn about various distance tsunami sources.

**Stress:**

Subduction zones are largely located along the volcanic mountain chains that make up the "Ring of Fire". They can generate tsunamis that sweep through the entire Pacific basin causing a tsunami risk to Washington coastal communities.

Due to the various tsunami sources on the "Ring of Fire", distant source tsunamis are more frequent than local source tsunamis. Historical records (up to 1854) and geologic investigations indicate that tsunamis have struck Washington's shores numerous times. While only one tsunami has caused major damage (1964 Alaska Earthquake), strong currents accompanying a tsunami threaten the maritime industry as well as individuals in and around the water. For example, a 1960 earthquake along the coast of Chile generated a tsunami causing nondestructive inundation at Grays Harbor, Tokeland, Ilwaco, Neah Bay, and Friday Harbor.

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Distant Tsunami



Slide 4. How Earthquakes Generate a Distant Tsunami

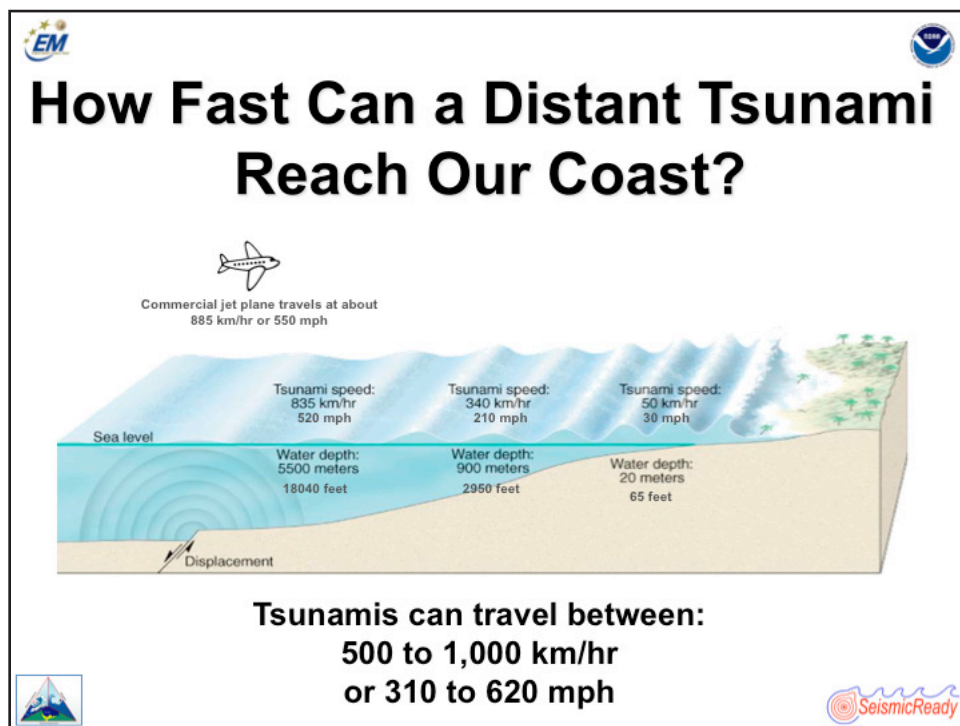
**Slide Learning Objectives:**

Understand the subduction process

**Stress:**

Subduction occurs when one plate slides under another plate that usually gets locked together. When the overriding plate breaks free it causes an earthquake. Upon release the seafloor (and the water above it) is raised, a tsunami is created.

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Distant Tsunami



Slide 5. Speed of a Tsunami

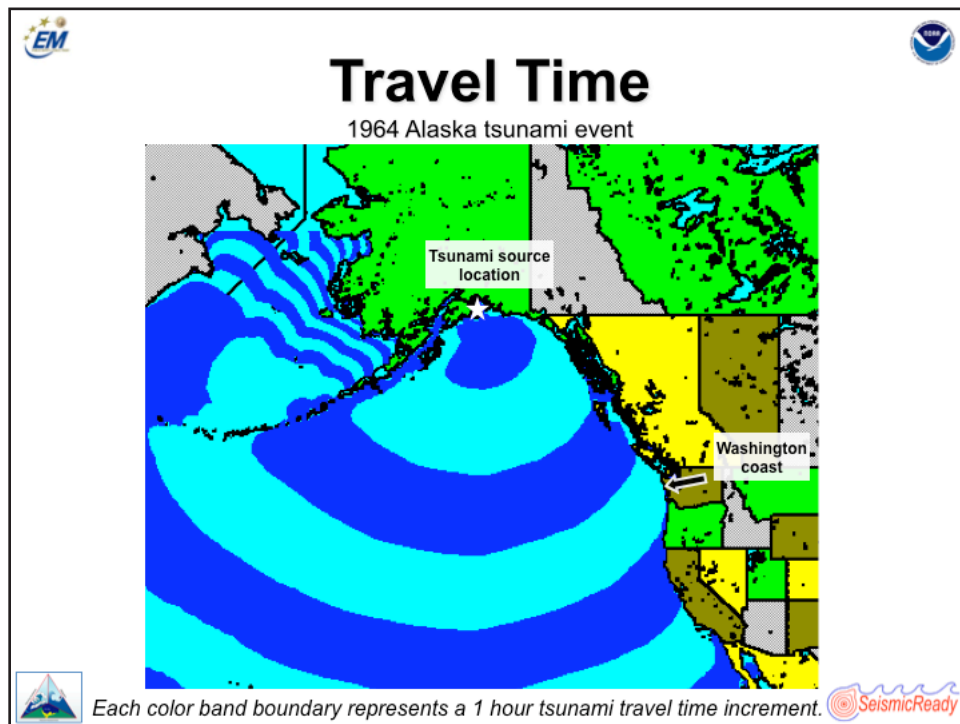
**Slide Learning Objectives:**

Learn the different speeds at which a tsunami travels.

**Stress:**

Shoaling occurs as the tsunami approaches land. Shoaling is when a wave steepens and breaks because of decreasing depth.

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Distant Tsunami



Slide 6. 1964 Alaskan Tsunami Travel Time Map

**Slide Learning Objectives:**

Understand tsunami speed based on an actual event.

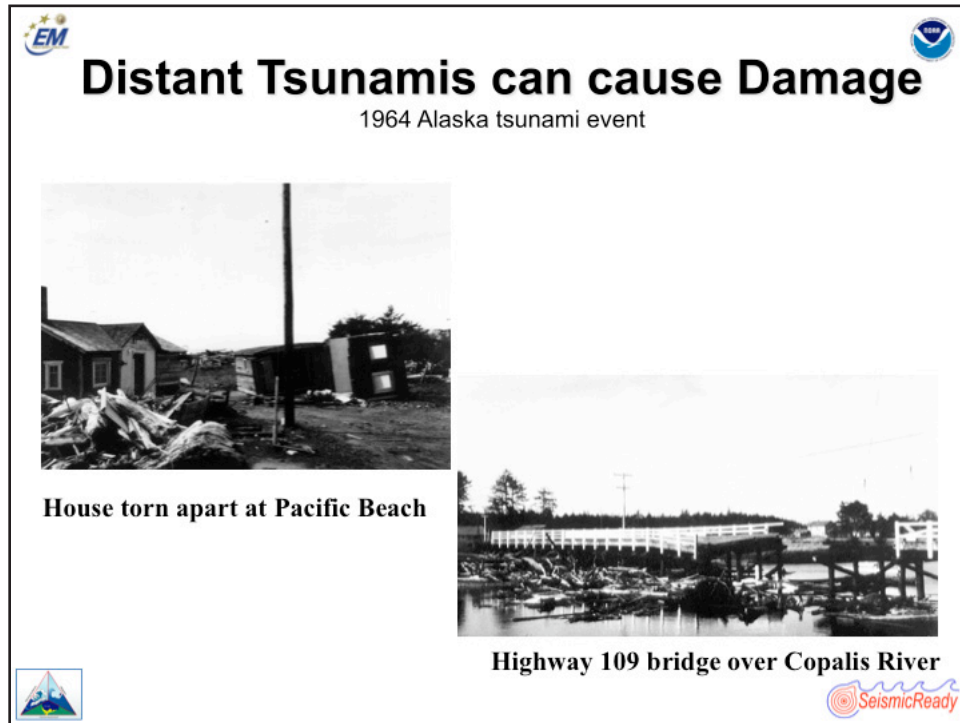
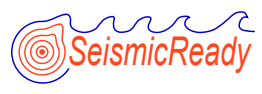
**Stress:**

A tsunami originating in Alaska can strike the Washington coast in 2 hours. The 1964 event, from a Mw 9.2 earthquake, was recorded with the following travel times:

- Neah Bay 3 hours 42 min
- Copalis 3 hours 54 min
- Friday Harbor 4 hours 54 minutes
- Iwalco 3 hours 59 minutes
- La Push 3 hours 49 minutes
- Seattle 5 hours 36 minutes

Wave heights range in Washington were between 5-15 ft.

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Distant Tsunami



Slide 7. Damage Caused by 1964 Alaska Tsunami Event



**Slide Learning Objectives:**

Understand the impact of a distant tsunami.

**Stress:**



While distant tsunamis have caused significant damage, deaths and injuries in Oregon and California, only one significant tsunami struck Washington's Pacific coast in recent history. The 1964 Alaska earthquake generated a tsunami that resulted in debris deposits throughout the region, minor damage in Ilwaco, damage to two bridges on State Highway 109, a house and smaller buildings being lifted off their foundations in Pacific Beach, and piling damaged at the Moore cannery near Ilwaco. The tsunami was also recorded inland in the Strait of Juan de Fuca (Friday Harbor), Puget Sound (Seattle), and the Columbia River (Vancouver) but caused no damage.





## Distant Tsunami: Recap

- Originates from a source that is far away from the site of interest, and takes 2 hours or longer to arrive after the triggering event.
- Washington is along the “Ring of Fire” which has many subduction zones that can trigger a tsunami.
- Distant source tsunamis are more frequent than a local tsunami.



Slide 8. Distant Tsunami Recap



### Slide Learning Objectives:

Summarize Clallam County’s distant tsunami scenarios.

### Stress:

Majority of tsunami watches and warnings will be from a distant event. We will have 2 hours or longer to prepare for an event and rely on the West Coast Alaska Tsunami Warning Center to provide critical information needed for decision-makers to call an evacuation. In 1964, an Alaskan earthquake caused a destructive tsunami. The largest wave entered Willapa Bay about 12 hours after the first one; the tsunami caused \$640,000 (2004 dollars) in damage. Since then, we have had a tsunami warning in 1999 and 2006 from Kuril Island earthquakes; as well as in 2005 from a California event (though it is not necessarily a distant tsunami). Distant events give the tsunami warning center time to issue official tsunami messages, based on sea level data. CNN and other major networks will also carry “breaking news” regarding the earthquake and tsunami. Based on information received by the Tsunami Warning Center, local and state officials will make the decision to issue evacuation orders to the public.







## Distant Tsunami and Response: In Brief

Key points:

- ✓ Source is distant – examples: Alaska, Chile, Kuril Islands
- ✓ No felt earthquake
- ✓ Official and unofficial information
- ✓ Evacuation starts with official warning

*Further discussion in “Response” training section.*



### Slide 9. Distant Tsunami Response

#### Slide Learning Objectives:



Briefly summarize Clallam County’s local tsunami warning and response.  
(Note: In depth discussion in “Response” section)

#### Stress:

*Key points:*



- Distant tsunami are generated hours away from Washington and people will not feel the ground shake from the earthquake.
- Distant events allow time for more detail information to be provided by the tsunami warning center to decision-makers and local/state government will provide official evacuation orders.





## Discussion Questions

- Where, what and how are distant tsunamis generated?
- Name the evidence that can support that a community has a distant tsunami hazard?



### Slide 10. Discussion Questions

#### Slide Learning Objectives:

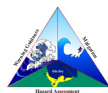
- Review learning points from presentation.
- Discussion questions for community workshop.

#### Answers:

*Answer question 1:* Distant tsunamis can be triggered on the “ring of fire” (on which we live) as it has numerous subduction zones. Subduction occurs when one plate slides under another plate that usually gets locked together. When the overriding plate breaks free it causes an earthquake. Upon release the seafloor (and the water above it) is raised, a tsunami is created. Distant tsunamis have been generated from Alaska, Chile and Kuril Islands in recent history.

*Answer question 2:* Only known distant tsunami to cause damage in WA is from the 1964 Alaska Earthquake. Several bridges and buildings and buildings were damaged.

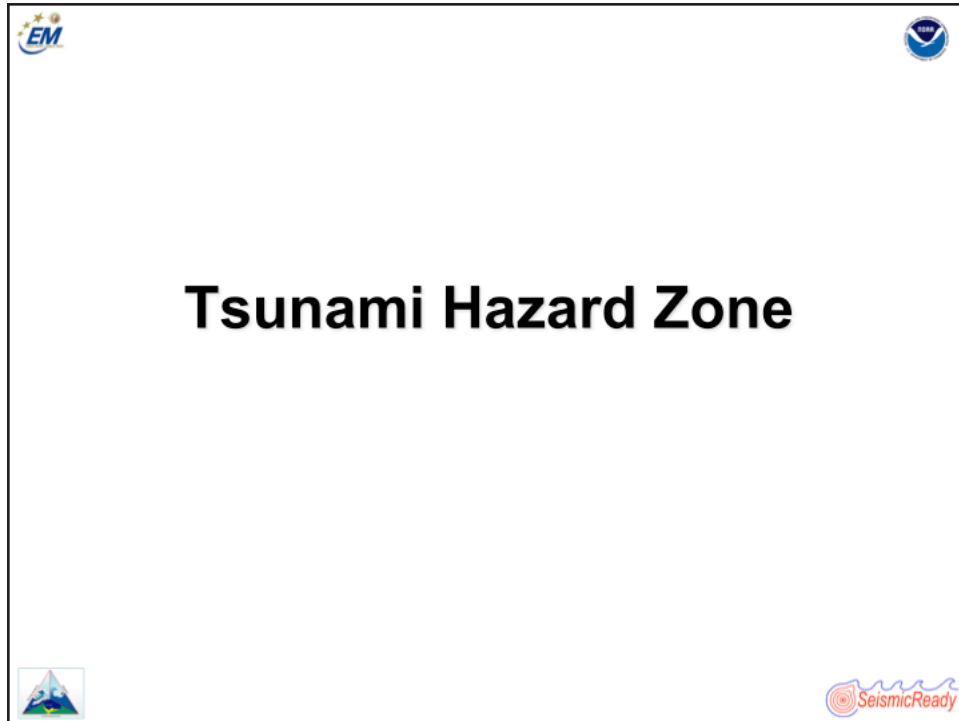
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Notes

***End of Section***

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Tsunami Hazard Zone

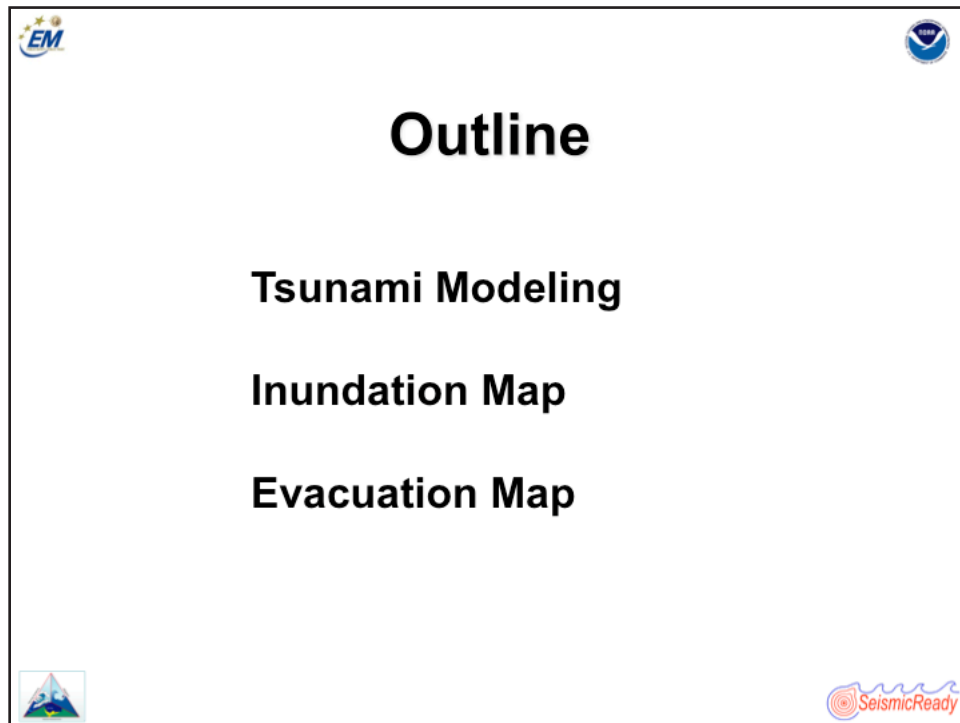


Slide 1.

**Slide Learning Objective:**

Introduce the Tsunami Hazard Zone topic.

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Tsunami Hazard Zone



Slide 2. Outline

**Slide Learning Objectives:**



Understand the presentation's outline.

**Stress:**

You will learn:



- What the tsunami hazard zone is and how it is determined (i.e. modeling and inundation maps).
- What we do with this information (i.e. evacuation maps).





## Tsunami Modeling

What is tsunami modeling?  
Computer simulations of hypothetical & past tsunami events



Slide 3. Tsunami Modeling

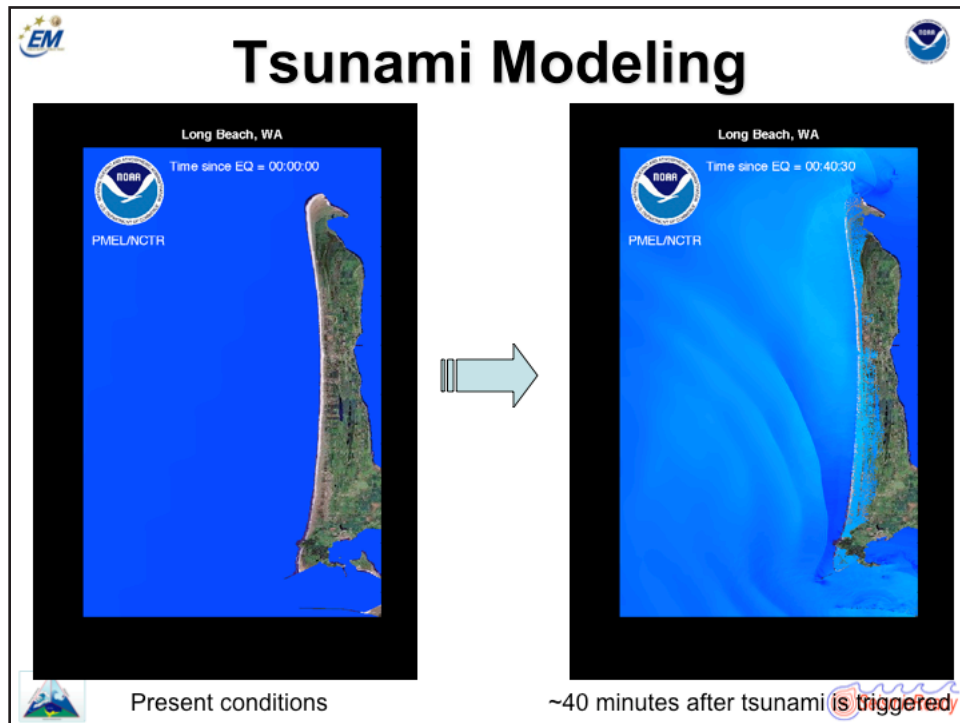
**Slide Learning Objectives:**

Learn about tsunami modeling.

**Stress:**

Modeled faults are used to create sea deformation that propagates onto the coast line. Tsunamis are infrequent, so models can help us understand probable tsunami scenarios as well as worst case scenarios.

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Tsunami Hazard Zone



Slide 4. Tsunami Modeling

**Slide Learning Objectives:**

Understand the tsunami model process.

**Stress:**

The tsunami source is based on prior work by Walsh et al., (2000) that simulates a great Mw 9.1 Cascadia Subduction Zone earthquake with an asperity off the coast of northern Washington. Details of this scenario and the model results are provided in Venturato et al., 2007. These animations depict wave propagation and inundation.



This is just ONE modeled event used to create an inundation map.

Link to animation:

[http://nctr.pmel.noaa.gov/animations/inun\\_animation\\_lb\\_logo.mov](http://nctr.pmel.noaa.gov/animations/inun_animation_lb_logo.mov)

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Tsunami Hazard Zone







## Modeling to Inundation Map

Why is tsunami modeling important?

Simulate a tsunami's:

- arrival time at coast
- height of waves
- distance reached inland
- strength of currents

Result ➡ inundation map for a community



Slide 5. Modeling to Inundation Map

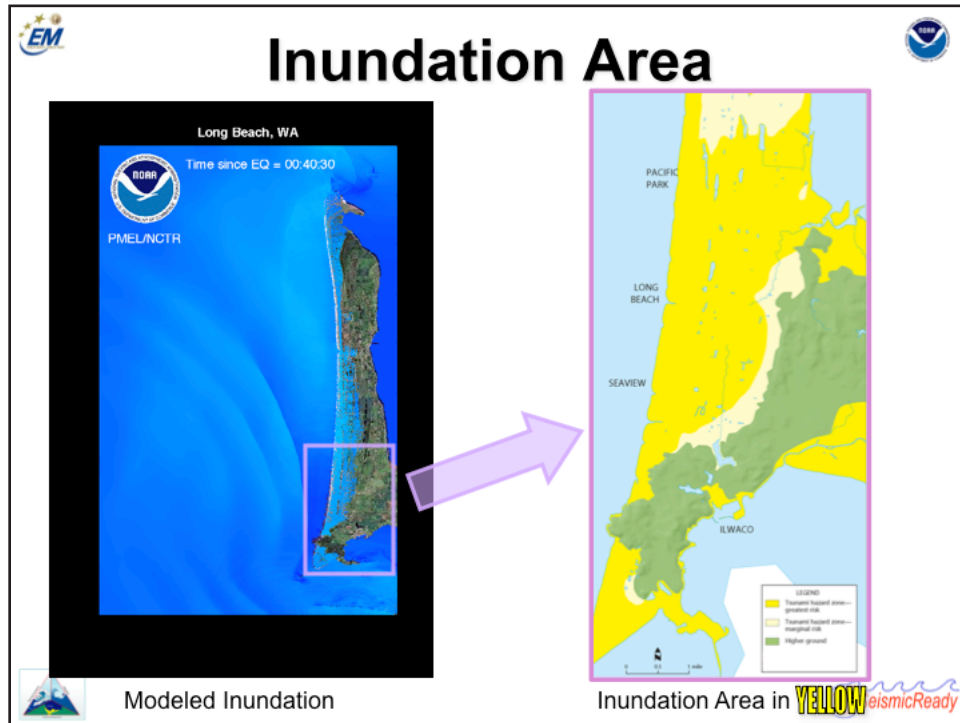
**Slide Learning Objectives:**

Understand the tsunami model outputs.

**Stress:**

Often more than one tsunami scenario is utilized to develop an inundation map. Tsunami source location, magnitude and other attributes result in distinct affects to a particular location. Thus, it is imperative to utilize more than one credible scenario to create a tsunami inundation map.

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Tsunami Hazard Zone



Slide 6. Inundation Area

**Slide Learning Objectives:**

Understand inundation map development.

**Stress:**

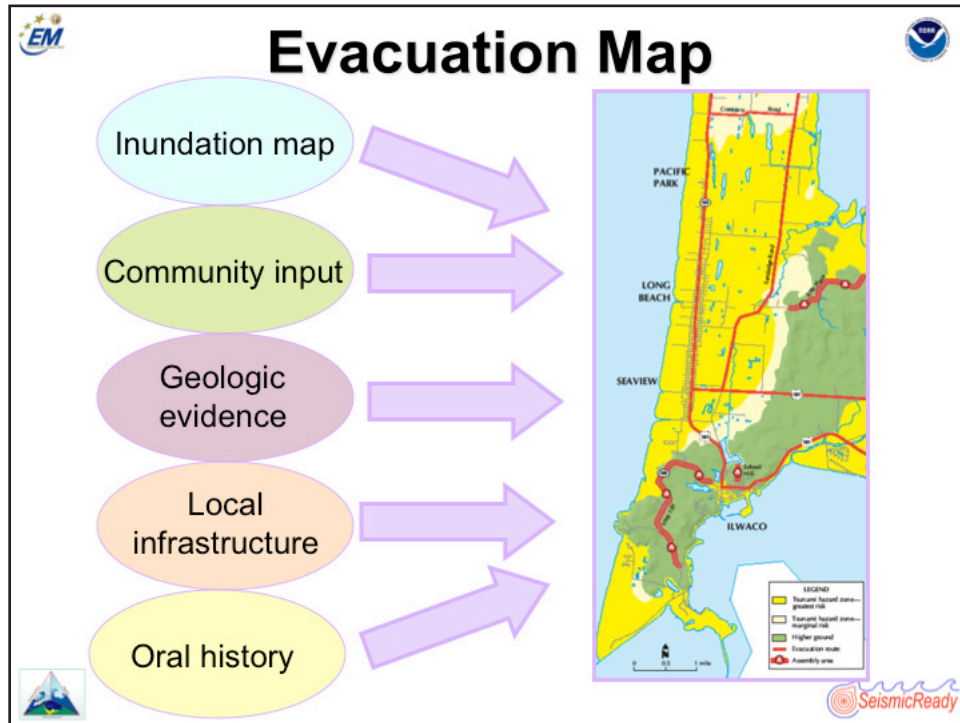
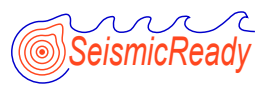
The modeled inundation, *left*, contributes to developing the inundation area, *right*, in yellow. Many modeled scenarios are used to establish inundation area not just the one presented. Thus, inundation area is not an exact match to modeled inundation.

Once an inundation line is drawn, the line is not permanent. New techniques for tsunami modeling are always improving the capacity to create more effective inundation maps. Also, difficult to detect land changes (e.g. topography and bathymetry) can effect tsunami inundation mapping. Consequently, inundation maps should be used for guidance in planning not as definitive and permanent maps.

Washington State evacuation maps:

[http://www.emd.wa.gov/hazards/haz\\_tsunami.shtml](http://www.emd.wa.gov/hazards/haz_tsunami.shtml)

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Tsunami Hazard Zone



Slide 7. Evacuation Map

**Slide Learning Objectives:**

Understand evacuation map development.

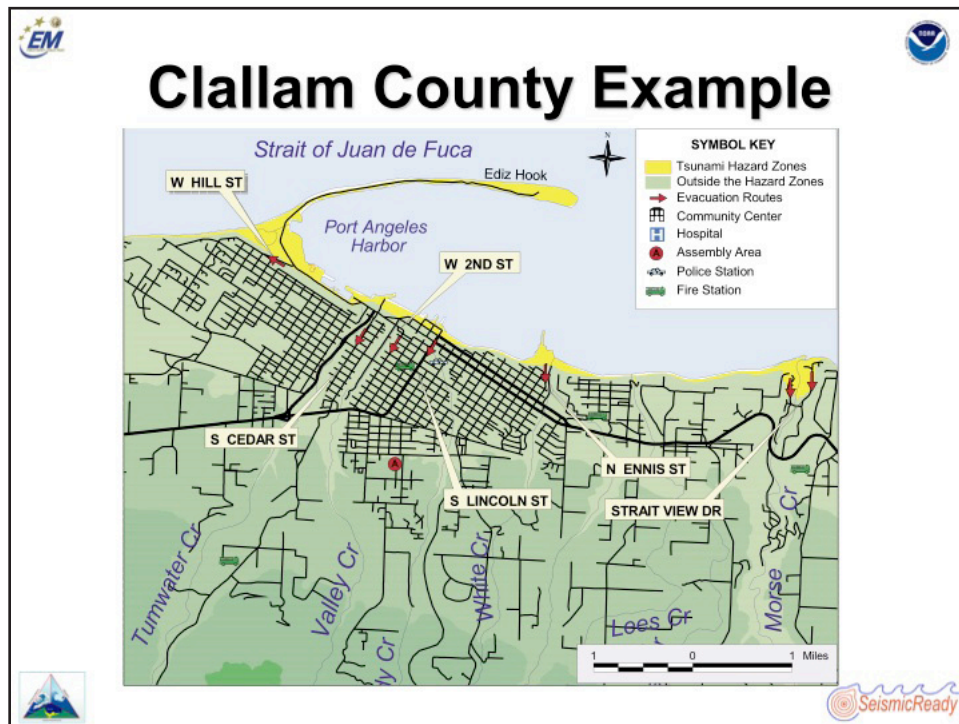
**Stress:**

Evacuation maps, routes and assembly areas can be identified once inundation modeling and mapping is developed.

Special needs populations should determine evacuation assembly areas or vertical evacuation refuge sites. Special needs populations must be able to reach safe sites within the the expected wave arrival time for safe evacuation.

Tsunami Evacuation Map Brochures should be developed for visiting, or tourist populations. Tsunami evacuation routes should be adequately marked with signage. Official tsunami signage creates pre-event awareness and improves life safety.

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Tsunami Hazard Zone



Slide 8. Clallam County Example

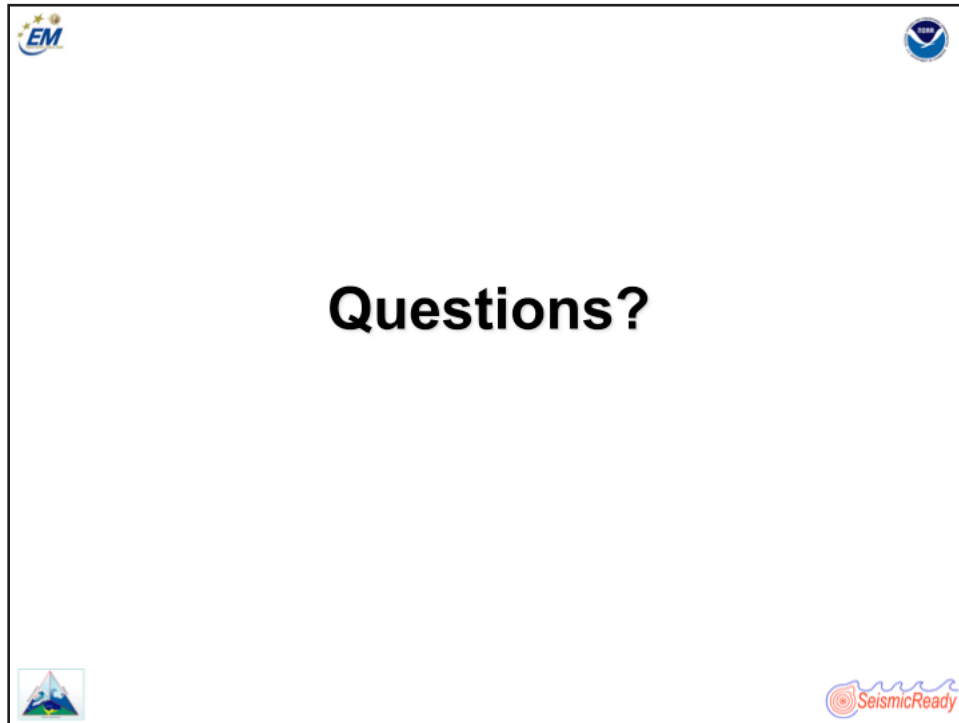
**Slide Learning Objectives:**

Understand the evacuation map process has been used in Clallam County.

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Tsunami Hazard Zone



www.emd.wa.gov  
Washington State  
Emergency Management

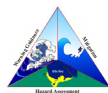


**Slide 9. Questions**

**Slide Learning Objectives:**

- Review learning points from presentation.
- Discussion questions for community workshop.

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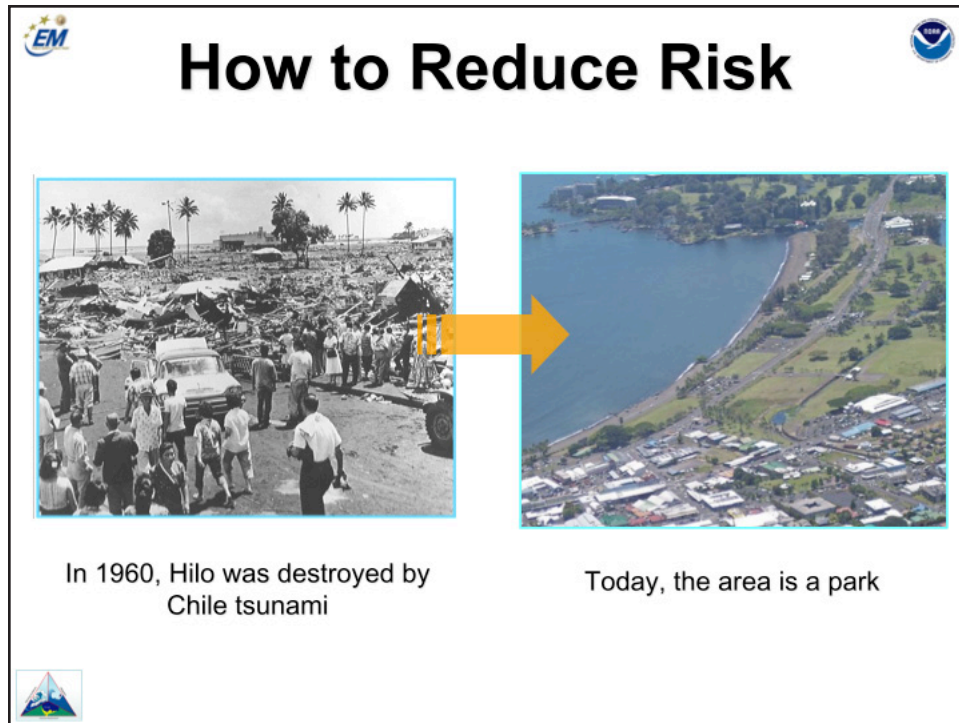
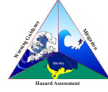


Notes

***End of Section***

# Clallam County ***Train-the-Trainer***

## How to Reduce Risk



Slide 1.

### **Slide Learning Objective:**

Introduce Risk Reduction topic.



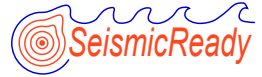
### **Stress:**

Hilo, Hawaii, has been destroyed by several major tsunamis which includes the 1960 Chile Tsunami, *right photo*. Today, the city has been moved back and the area where the city once was is now a park – Land use planning is one way to help reduce the risk of tsunamis and the economic impact that a tsunami can have on a community. *Photo Sources: Hilo, 1960: Honolulu Advertiser; Hilo, 2010: Google Maps, DigitalGlobe*

Evidence of past tsunami events identify that tsunamis are a significant threat to Clallam County coastal communities from both a local (Example: 1700 Cascadia Subduction Zone) and distant (Example: 1964 Alaska Earthquake/Tsunami) events.



Over the years, these coastal communities have grown in both population and built environment increasing their vulnerability. Results of a perception study of residents and tourists on the outer Washington coast indicate that hazard awareness was high among survey participants, but awareness levels did not translate into preparedness actions (Johnston and others, 2005). In an effort to correct this deficiency, you will be introduced to the use of evidence-based approaches in social and behavioral sciences that are tailored to a community's specific risk and vulnerability.

Clallam County  
***Train-the-Trainer***  
How to Reduce Risk



# Outline

- Vulnerability
- Evacuation
- Preparedness
  - Personal
  - Neighborhood
  - Hospitality Industry



Slide 2. Outline

**Slide Learning Objectives:**



Understand the presentation's outline.

**Stress:**

You will learn:



- How to identify vulnerability
- Challenges in evacuation
- Steps towards preparedness





## Why We Discuss Vulnerability

- **Behavior:** Tsunami is an uncontrollable event BUT consequence is controllable
- **Audience:** how they learn and how they will respond to tsunami
- **Needs:** response efforts to audience



Slide 3. Why We Discuss Vulnerability

### Slide Learning Objectives:

Learn about tsunami modeling.

### Stress:

*Change behavior*

Use evidence-based approaches in social and behavioral sciences that present an uncontrollable event (tsunami hazard) and controllable consequence (actions an individual can take to reduce their vulnerability). Individuals are more inclined to act on hazard education information if they believe their present actions can reduce their vulnerability (Paton et al., 2008).

Example: Strong coastal ground shaking (uncontrollable) = individual correctly interprets the natural cue, (their action) Drop, Cover and Hold and head inland and to high ground immediately (Controlled).



### Target your audience

Develop your talk based on the level of knowledge and preparedness for the tsunami hazard, needs of the audience (example: special needs population, different cultures and languages), and include personal stories of tsunami survivors to provide context. Social science studies suggest people are more willing to be educated about and/or prepare for a tsunami if they have experienced one. In communities where there haven't been recent tsunamis to give personal experiences use tribal oral histories of tsunami preparedness passed down through the generations and recent tsunami survivor stories (McMillan and Hutchinson, 2002)

# Clallam County ***Train-the-Trainer***



## How to Reduce Risk





### Why We Discuss Vulnerability

- **Behavior:** Tsunami is an uncontrollable event BUT consequence is controllable
- **Audience:** how they learn and how they will respond to tsunami
- **Needs:** response efforts to audience



Slide 3. Why We Discuss Vulnerability

### (continued)

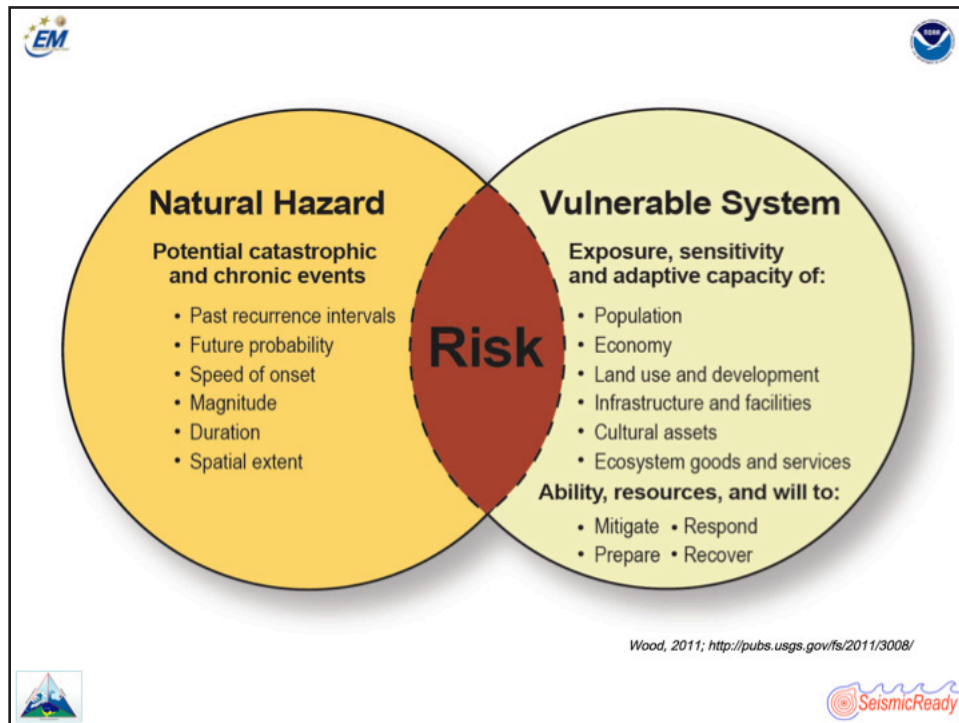
*Targets response efforts to audience needs*

Each coastal community has different vulnerabilities to tsunamis. Understanding them allows you to address their specific needs.

Example: Areas in Clallam County with no high ground and/or with predominantly retirees may be interested in vertical evacuation structures. However, a community with predominantly young adults that can reach high ground within minutes may not require such a significant investment.

# Clallam County **Train-the-Trainer**

## How to Reduce Risk



Slide 4. Risk

### Slide Learning Objectives:

Understand how vulnerabilities impact risk.

### Stress:

Risk of future tsunami disasters is a function of predicted tsunamis and the vulnerable human systems that occupy tsunami-prone areas (fig. 3; Wood, 2007).



**Discovering Societal Vulnerability in the community**

**I. Exposure** Who and what are in tsunami hazard zones?

**II. Sensitivity**

- Who will have difficulty evacuating?
- What conditions will complicate evacuation?

**III. Adaptive Capacity**

- How prepared are individuals to evacuate?
- How prepared is the community to respond?

Slide 5. Discovering Societal Vulnerability

**Slide Learning Objectives:**

Understand how to determine a community's vulnerabilities.

**Stress:**

By understanding a community's hazard exposure, physical vulnerability, and social vulnerability, evacuation planning, public education, and other preparedness and response program can be developed.



*Exposure*

Population, assets and resources that are in the tsunami hazard zone (Number and types of individuals including tourists and employees that transit into the tsunami hazard zone, businesses, cultural and natural resources, roads, bridges, utilities). For example, in Port Angeles approximately 19% of residents of people living in the Tsunami Hazard Zone are over 65 years old and 38% of residents in the hazard zone are female (many of which are single parent/head of household). At the Makah Indian Reservation, 802 residents, representing 59 percent of the population, live in the tsunami inundation zone. This type of information will help you develop your briefings to meet communities special needs.

# Clallam County **Train-the-Trainer**

## How to Reduce Risk



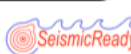



### Discovering Societal Vulnerability in the community

**I. Exposure**      Who and what are in tsunami hazard zones?

**II. Sensitivity**      •Who will have difficulty evacuating?  
                                 •What conditions will complicate evacuation?

**III. Adaptive Capacity**      •How prepared are individuals to evacuate?  
                                 •How prepared is the community to respond?



Slide 5. Discovering Societal Vulnerability

**(continued)**

### *Sensitivity*

Asset characteristics and implications of a tsunami (What conditions will complicate?). For example, Port Angeles and other areas in the county have significant populations of over 65 years old living in tsunami hazard zone. These populations will require assistance or additional time to evacuate. Single-parent households may have unique evacuation and recovery issues, as they are more likely to have limited mobility during an evacuation and fewer financial resources to draw upon after a disaster (Laska and Morrow, 2007).

### *Adaptive Capacity*

Ability to manage risk, adapt during crisis and recover from tsunami. How prepared is the community to respond? Is regular public education given and tsunami drills done? How will individuals receive warning? Are people educated on the type of warning systems in the community and know the natural queues for a local tsunami event?

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How to Reduce Risk



**How do I find information on Social Vulnerability?**

**Overnight tourist facilities in tsunami hazard zone**

**Public venues in tsunami hazard zone**

Information specific to Washington communities

Slide 7. Finding Information on Social Vulnerability

**Slide Learning Objectives:**

Identify social vulnerability resources.

**Stress:**

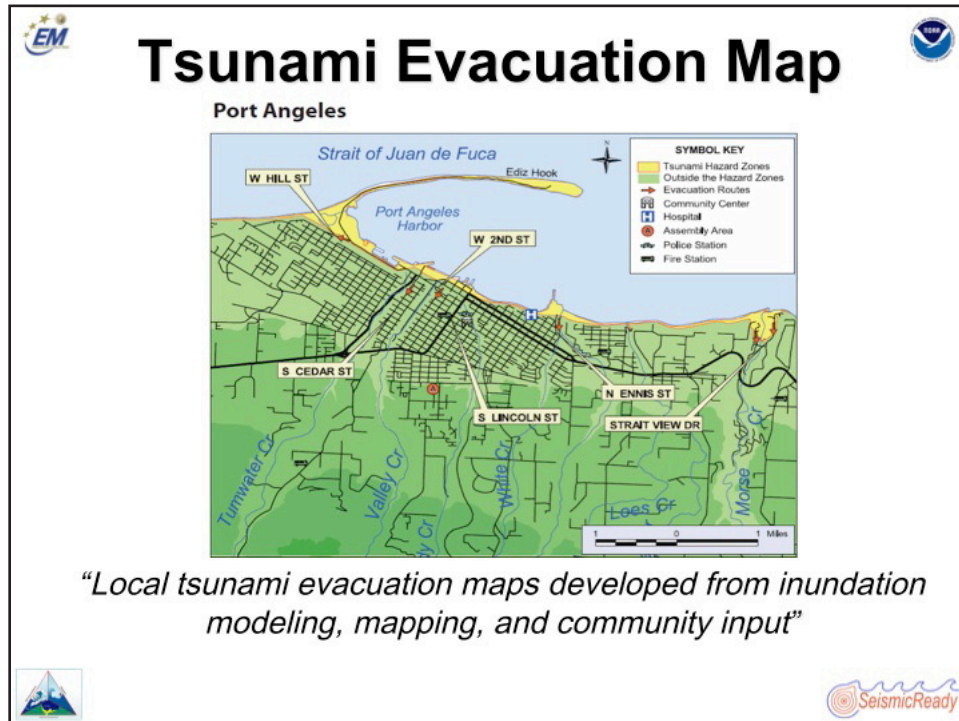
U.S.G.S. report describes tsunami-prone landscapes and documents geographic variations in community vulnerability to Cascadia Subduction Zone related tsunamis on the open-ocean and Strait of Juan de Fuca coasts in Washington. As you develop community specific training in Clallam County, use the document to grasp the community's specific exposure and sensitivity to tsunamis. It will help you understand who you are trying to motivate and their capacity to respond. This tool along with evidence-based approaches in public education and preparedness in the community will effectively motivate your audience to take protective measures in response to a tsunami warning.

Wood, Nathan, and Soulard, Christopher, 2008, "Variations in community exposure and sensitivity to tsunami hazards on the open-ocean and Strait of Juan de Fuca coasts of Washington," U.S. Geological Survey Scientific Investigation Report 2008-5004, 34p.

Link to report:

<http://pubs.usgs.gov/sir/2008/5004/>

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How to Reduce Risk



Slide 7. Tsunami Evacuation Map

**Slide Learning Objectives:**

Understand how vulnerabilities are used to develop evacuation maps and routes, as well as assembly areas.

**Stress:**

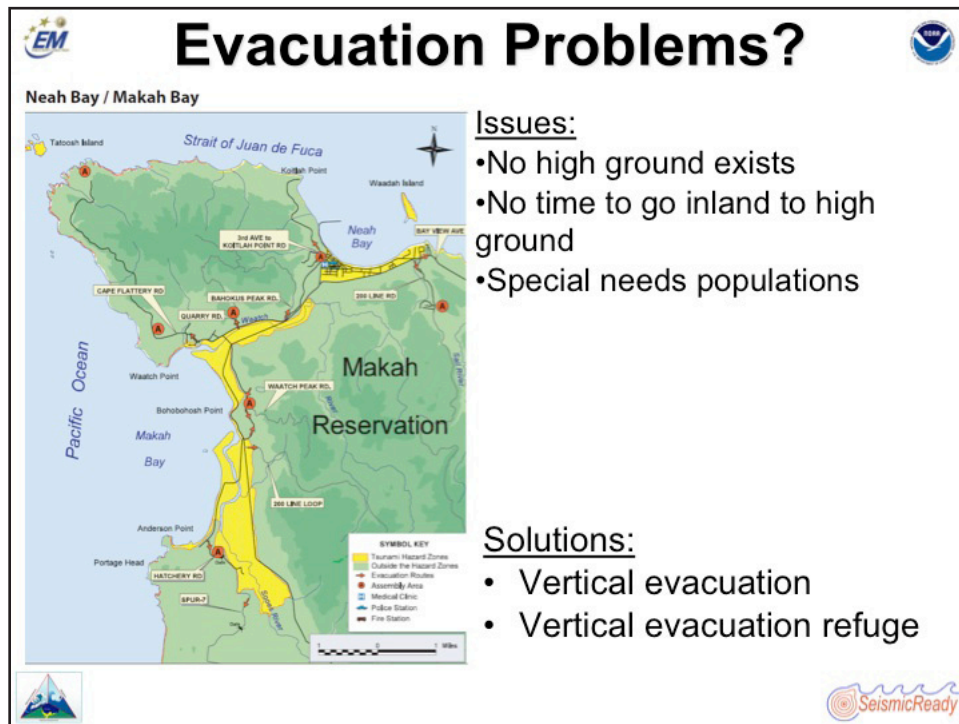
Once tsunami inundation maps are developed, communities develop evacuation maps which are then placed in a tsunami brochure. The brochure provides residents and tourist with actions they take for preparing and reacting to a tsunami event.

When planning and developing tsunami evacuation routes, a community uses exposure and sensitivity data to identify the location of special population groups lacking the ability to anticipate, cope with, resist and recover from the impacts of a tsunami. Those that are in need of help to evacuate (without cars, the elderly, handicap etc) should talk to neighbors and community support groups (example: Map your neighborhood program) to pre-arrange evacuation to high ground.

Remember that special populations in the community will require additional time to arrive to an evacuation assembly area. It is recommended that they familiarize themselves with the evacuation routes closes to them and walk the routes to see how long it takes to get to an assembly area. That time is then compared to the expected wave arrival time identified by the tsunami model that was used to develop the inundation map.

*During a local-source event, evacuation on foot may be their only option. Debris from the earthquake and flooding may increase the time it takes to get to an evacuation assembly area or to high ground.*

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How to Reduce Risk



Slide 8. Evacuation Problems

**Slide Learning Objectives:**

Understand types of challenges encountered in evacuation.

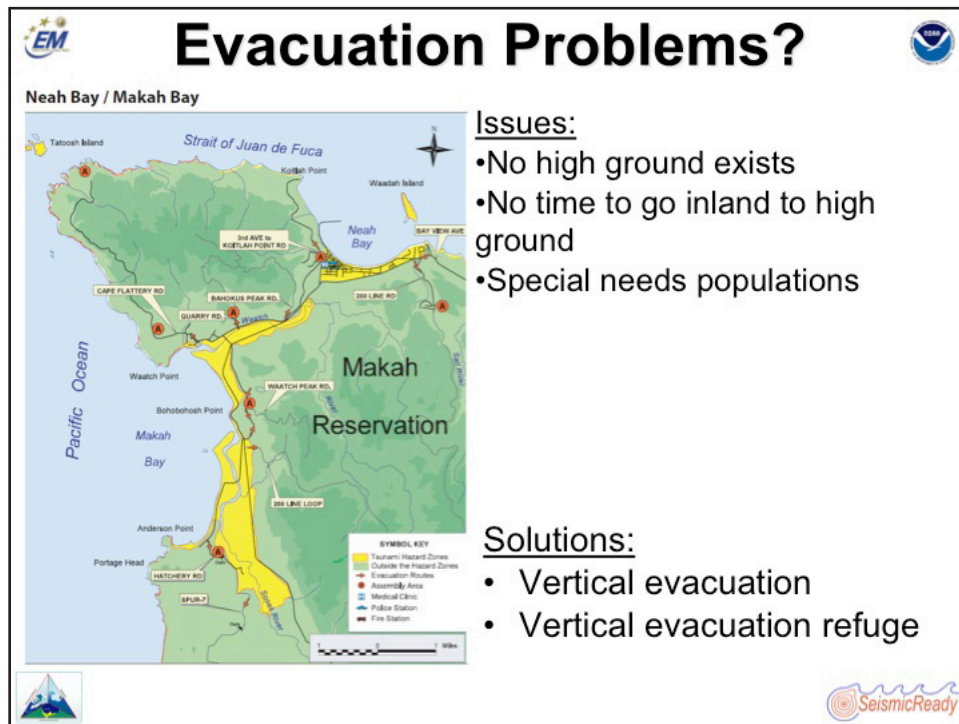
**Stress:**

In some locations, high ground may not exist, or tsunamis triggered by local events may not allow sufficient warning time to evacuate to high ground. The only solution is to evacuate in place, meaning vertical evacuation into the upper levels of structures. Things to consider for vertical evacuation are:

- Reinforce concrete buildings do better than wood frame building
- Look for a structure that is back away from the beach and on higher ground – it will help reduce tsunami depth and velocity.
- Debris such as cars, trees, logs and damaged building can cause damage to a building by a tsunami wave and
- Avoid hazardous material sites, if possible.

There now is guidance out on vertical evacuation structures: FEMA P646, Guidelines for Design of Structures for Vertical Evacuation from Tsunamis and FEMA P646A, Vertical Evacuation from Tsunamis: A Guide for Community Officials. The state tsunami program is working with local officials on the development and funding of these sites in at-risk communities that have no high ground. These structures designed for vertical evacuation from tsunamis are called vertical evacuation refuges. They are designed for short-term protection (12-24 hours), of sufficient height to elevate evacuees above the level of tsunami inundation, and designed to withstand an earthquake and resist tsunami loads.

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How to Reduce Risk

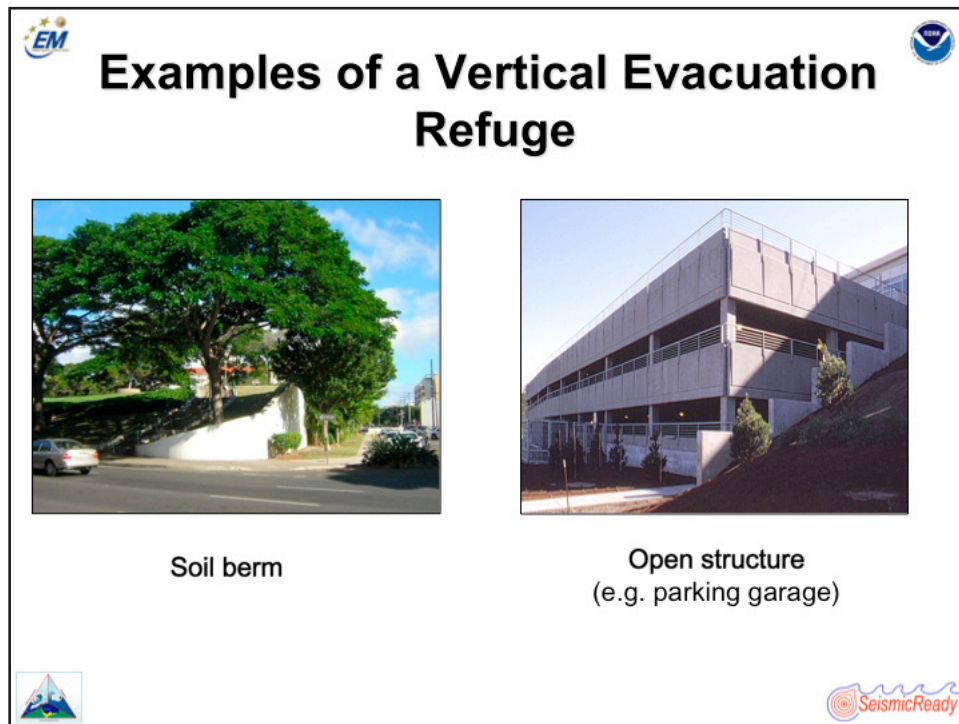


Slide 8. Evacuation Problems

(continued)

If you can't evacuate inland and there are no high structures nearby, then you should find the tallest, sturdy structure and climb up and cling to it until the wave passes. In some cases, this might only be a strong tree or utility pole. If you're swept up by a tsunami, look for something to help you stay afloat, and to protect you from dangerous floating debris like houses, cars, and trees.

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How to Reduce Risk



Slide 9. Examples of a Vertical Evacuation Refuge

**Slide Learning Objectives:**



Understand types of vertical evacuation refuges.

**Stress:**

Berms can be combined with a community open space. Ocean facing walls can deflect incoming waves, while sloped sides provide for quick access. Parking garage is an open structure allows water to pass through with minimal resistance, and interior ramps allow for easy ingress and vertical circulation.


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How to Reduce Risk







## Preparedness is a shared RESPONSIBILITY

1,500 people died in this train while two reinforced concrete buildings a few steps away were virtually undamaged



*“To survive a tsunami, individuals in tsunami prone communities must have the knowledge to take correct actions quickly”*



Slide 10. Preparedness is a Shared Responsibility

**Slide Learning Objectives:**

Understand importance of preparedness.



**Stress:**

Understanding the hazard and appropriate actions to take can save lives.

Make sure your briefings provide a consistent message that is being used throughout Clallam County. An inconsistent message will cause confusion and lead to a wrong action. Always end your public education messages with an action.

Example public education message: When you are in a tsunami hazard zone you must know the natural cues of a tsunami (i.e. ground shaking, sea level changes, a loud roar). **Take ACTION** -> *Head to high ground immediately*







## Personal Preparedness Actions

**Citizens must:**

- Know the Tsunami Hazard for their community
- Have a copy of the community's Tsunami Evacuation map/brochure
- Know the evacuation routes and assembly area
- Have a family emergency plan
- Know where each family member would go for various scenarios
- Practice the plan
- Reeducate on a regular basis
- Have a pre-packed emergency kit

*"Be prepared to be self-sufficient for multiple days"*



Slide 11. Personal Preparedness Actions

**Slide Learning Objectives:**

Identify basic personal preparedness actions.



**Stress:**

Based on our discussion of "Why we discuss vulnerability", public education must not focus on the uncontrollable tsunami hazards. Instead, focus should be on individual actions that can reduce a tsunami's impact.

The above (in slides) are positive action messages citizens can take to survive a tsunami. As you go through each one, ask the audience to comment and solicit their input – this is one way to help them buy-in to self preparedness and understanding they can control the outcome of a tsunami strike


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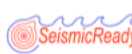



## Neighborhood Preparedness

- First Responders may be overwhelmed and unable to immediately assist individuals
- Neighbors will be the first ones to offer assistance.
- Map Your Neighborhood program provides excellent guidance



*In a disaster, your most immediate source of help are the neighbors living around you*



**Slide 12. Neighborhood Preparedness**

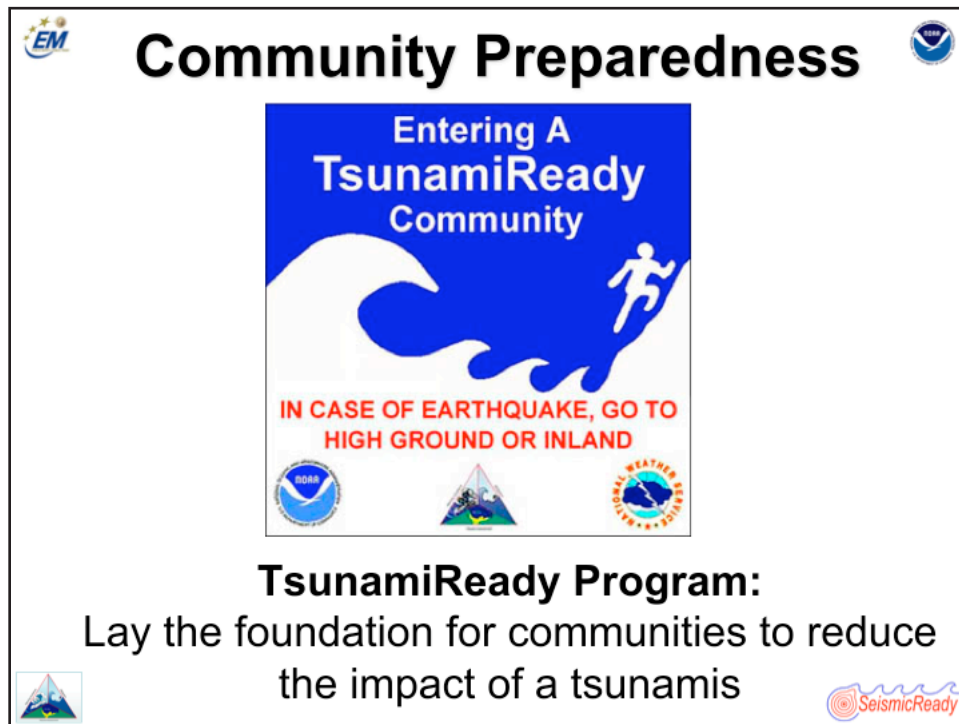
**Slide Learning Objectives:**

Understand importance of neighborhood-based preparedness.

**Stress:**

*Action messages to convey to public:*

- Stay informed
- Take care of yourself and help others
- Help create a MYN in your neighborhood



Slide 13. Community Preparedness

**Slide Learning Objectives:**

Understand TsunamiReady Program and its benefits.

**Stress:**

Minimum guidelines have been developed for communities and counties to follow for adequate tsunami readiness that encourage consistency in educational materials, response, and planning among coastal communities. The program recognizes communities that have taken the steps necessary to prepare their emergency response infrastructure and population for a tsunami emergency and who have increased public awareness and understanding of the tsunami hazard. Funding through the TsunamiReady Program and the National Tsunami Hazard Mitigation Program supports communities in meeting the guidelines to be recognized as "TsunamiReady."

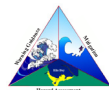
Clallam County is designated as TsunamiReady by the NWS. However, communities in the Clallam County can pursue their own TsunamiReady Status.



*For more information on the program contact:*

- Your local or state emergency management agency
- The Warning Coordination Meteorologist at your local NWS Forecast office (Seattle)
- The NWS TsunamiReady website: [www.stormready.noaa.gov](http://www.stormready.noaa.gov)
- National Tsunami Hazard Mitigation Program website: [www.nthmp.tsunami.gov/](http://www.nthmp.tsunami.gov/)

*A community that is designated as a "Tsunami Ready Community" does not mean that they are 100% prepared to respond to a tsunami.*

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How to Reduce Risk






## Hospitality Industry

*First line of contact with tourists*

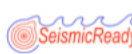

- Educate and train business on tsunami contingency planning
- Staff trained on what to do for a tsunami



DISASTER RESPONSE GUIDEBOOK for Hotels and Motels on Washington's Coast

Washington Military Department  
Emergency Management Division  
July 2019

*Resource for Hotels & Motels on Washington Coast is available!*



### Slide 14. Hospitality Industry

#### Slide Learning Objectives:

Identify resources available for the hospitality industry.

#### Stress:

*Disaster Response Guidebook for Hotels and Motels contains:*

- Checklist for tsunami warning and evacuation
- Provide individual staff training
- Provide business with a tone alert radio and instructions
- Provide outreach materials for customers and for rooms

#### Note:

If available ask WA State Tsunami Program brief this program to your audience.

Historical Note: The program was first started in Ocean Shores with the help of the Shilo Inn. The program is growing and embraced by the hospitality industry in that community.

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[www.emd.wa.gov](http://www.emd.wa.gov)  
Washington State  
Emergency Management

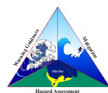


**Slide 15. Questions**

**Slide Learning Objectives:**

Review learning points from presentation.

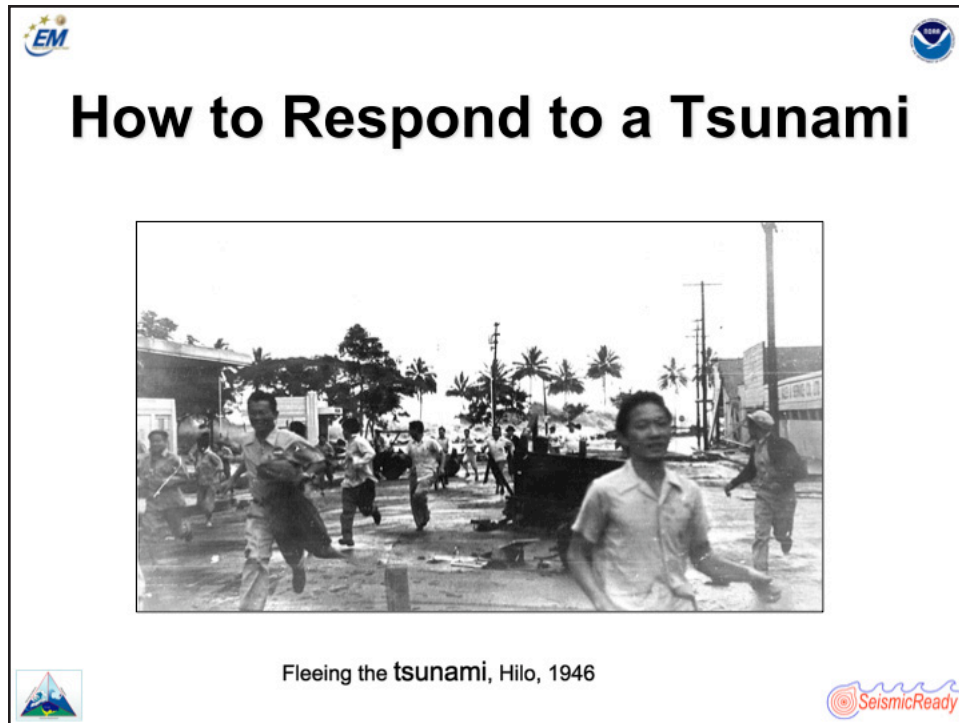
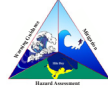
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Notes



Notes

***End of Section***

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Tsunami Response



Slide 1.

**Slide Learning Objective:**

Introduce the topic.

**Stress:**

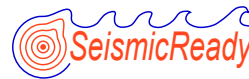
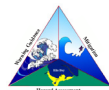
Photo shows people fleeing in Hilo, Hawaii. An earthquake occurred on Apr 1, 1946 in the Aleutian Islands of Alaska. Near the source of the earthquake, at Unimak Island, huge tsunami waves reached more than 100 feet above sea level and destroyed completely the newly built, U.S. Coast Guard's Scotch Cap lighthouse. All 5 men of its crew were killed. The lighthouse was a steel-reinforced concrete structure and its base was at about 90 feet above sea level. To Unimak Island and other area of Alaska this was a local event giving no warning other than natural cues. The tsunami arrived 4.9 hours in Hilo after the tsunami was generated. It caused \$26 million (1946 dollars) and 96 people lost their lives. For Hilo, this was a distant tsunami event.



There was no Tsunami Warning Center in 1946 but if people would have been educated on the tsunami hazard and understood tsunami natural cues, lost of life in Hilo would have been minimal to none.

Source: Bishop Museum Archives

Clallam County citizens must understand that they may deal with either a local tsunami (example: 1700 Cascadia Subduction Zone Earthquake/Tsunami) or a distant tsunami (example: 1964 Alaska Earthquake/Tsunami). The response for both types of tsunamis are different – their lives and those of their love ones depend on the correct response actions.



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**Tsunami Response**





## Outline

- **Local Tsunami Response**
- **Distant Tsunami Response**
  - Tsunami Alerts
  - Cancellation versus All-Clear
  - Key Official Communication Systems
  - How People get the Warning
- **How to Improve Tsunami Response**



Slide 2. Outline

**Slide Learning Objectives:**

Understand the presentation's outline.

**Stress:**

*Local Tsunami Response*

What does it mean, how will people get the warning and what actions for a local response is required



*Distant Response*

What does it mean and what type of response actions should the public expect

- Type of messages (Tsunami Alerts) that the public will see
- Type of communication systems in WA communities and how they work
- How people get the warning



*How can we improve tsunami response* in the community that will help them make the appropriate response decisions to a tsunami strike.





## Local Tsunami

- **Earthquake ground shaking means**
  - Roads impassable and bridge damaged
  - Buildings collapsed or severely damaged
  - Utility and communications systems disrupted or destroyed
- **Tsunami means**
  - Tsunami strikes within minutes after earthquake
  - Series of waves striking the coastline for hours
  - Debris (floating)
  - HAZMAT spills
  - Additional damage adding to earthquake impacts



Slide 3. Local Tsunami

### Slide Learning Objectives:



Understand immediate impact in a local tsunami event.

### Stress:

A local Cascadia event will require the public (as well as responders) in Clallam County to deal with the earthquake and its consequences. A major earthquake can destroy the built environment that will hamper the evacuation of the public to higher ground – the public must consider extra time needed for evacuation and have a plan that helps support special needs population. Local response will mean that the public will have to be prepared to self-evacuate on the natural cues and not depend on response personnel to be available to support evacuation out of the tsunami hazard zone.



In a local event, the tsunami will arrive within 30 minutes of the earthquake to Neah Bay though arrival would be within 1 ½ hours to Port Angeles (Wave arrival time based on modeling and inundation mapping data and identified in their perspective tsunami brochure). Some areas could also be flooded by land changes that the public will further have to deal with. The tsunami strike can last for hours that will be a series of waves. The first wave may not be the most damaging and people may have to vertically evacuate to escape the tsunami and head to an evacuation assembly area as best they can. Be aware that secondary hazards such as fire and other HAZMAT that can be associated with the tsunami and will need to be dealt with both during evacuation and during response before an “all clear” can be given by local authorities to return back to the tsunami hazard zone.





## Local Tsunami Response

- How will the community be notified?
  - **Natural cues are the warning notification!**
    - Little or no official warning disseminated in a timely manner



Slide 4. Local Tsunami Response

### Slide Learning Objectives:

Understand natural warning signs.

### Stress:

For local events natural cues will be your warning notification. Know these natural cues:



- Very strong ground shaking lasting up to several minutes from a Cascadia Subduction Zone
- Unusual ocean activity, especially if the ocean recedes seaward exposing the sea bottom, rocks and fish, or the ocean rapidly rises in elevation looking like a wall of water
- Loud roaring sounds from the ocean, like an approaching airplane or train.

These are natural warnings and mean that a tsunami is on its way and head to high ground immediately.

### Examples of the importance of understanding natural warnings:



Understanding natural warning signs saved thousands of lives during the December 26, 2004 Indian Ocean Tsunami, the September 29, 2009 South Pacific Tsunami in American Samoa and Samoa, and the February 27, 2010 Chile Tsunami. Survivors tell of the loud roar sounding like an airplane or train as the tsunami approached. Immediately heeded, these important warning signs gave people time to escape the dangers of a tsunami. On February 27, 2010 in Chile, the strong coastal earthquake shaking was the first natural warning that woke up many at 3:30 am early that morning.





## Local Tsunami Response

- How will the community be notified?
  - Natural cues are the warning notification!
    - Little or no official warning disseminated in a timely manner



Slide 4. Local Tsunami Response

**(continued)**



Example public education messages:

1. Know tsunami natural cues
2. Drop, Cover and Hold for strong ground shaking
3. Head inland and to high ground immediately

Tsunami warning centers will get the warning message out quickly but may not be received in enough time to safely evacuate to high ground. Because the response actions will be immediate, the public will need to be prepared to respond to the event on their own and take immediate action to move to high ground.

Example public education message: Prepare to self-evacuate on natural cues

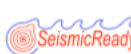





## Local Tsunami Response

What about first responders?

- Emergency Operation Center probably not activated to enable an evacuation during non-duty hours
- Little to no response personnel available to support evacuation



Slide 5. Local Tsunami Response

### Slide Learning Objectives:

Understand how local responders may be impacted during a local tsunami.

### Stress:



A local earthquake event has potential to cause damage to the built environment in Clallam County leaving the public and government officials to deal with destruction of the earthquake and a potential destructive tsunami within tens of minutes after the earthquake. Depending on the time of the event, there could be minimal response personnel available to deal with the response. The earthquake will cause major damage which will require responders to respond to the earthquake or hamper them supporting response efforts before they can support the tsunami evacuation of coastal residents. The public will need to be prepared to response to the event on their own.

Remember assembly areas are out of the inundation zone and where response personnel will focus their attention – however, food, water, etc., may not be available for some time. See the community tsunami brochure for items that should be a disaster supply kit.

### Example public education message:



- Develop a family plan
- Be familiar with emergency management and tsunami plans
- Know where the nearest assembly area is and how to get there
- Prepare a disaster supply kit





## Distant Tsunami Response

- Tsunami strikes within hours after earthquake
- Tsunami Warning Center sends Tsunami Alert and disseminated by state/local officials
- Emergency Operations Center activated
- Response plans implemented
  - including coordinated effort to support evacuation assembly areas and the response effort



Slide 6. Distant Tsunami Response

### Slide Learning Objectives:

Understand response community's process during a distant tsunami.



### Stress:

Distant tsunamis give the federal, state, and local governments time to assess the tsunami risk and make decisions on evacuations. Tsunami Warning Center will provide information on tsunami generation and recommended actions. They will provide updated information every 30 minutes. Emergency Operation Centers will be activated and staff with government officials who will coordinate the evacuation and response effort at all levels. Based on information from the tsunami warning center, decision makers will implement evacuation plans in impacted areas.

### Example public education message:



- Stay informed
- Follow instructions by local authorities





## Distant Tsunami Response

- Response/volunteers helping public evacuate
- Communication system overload



Slide 7. Distant Tsunami Response

**Slide Learning Objectives:**

Understand how vulnerabilities are used to develop evacuation maps and routes, as well as assembly areas.

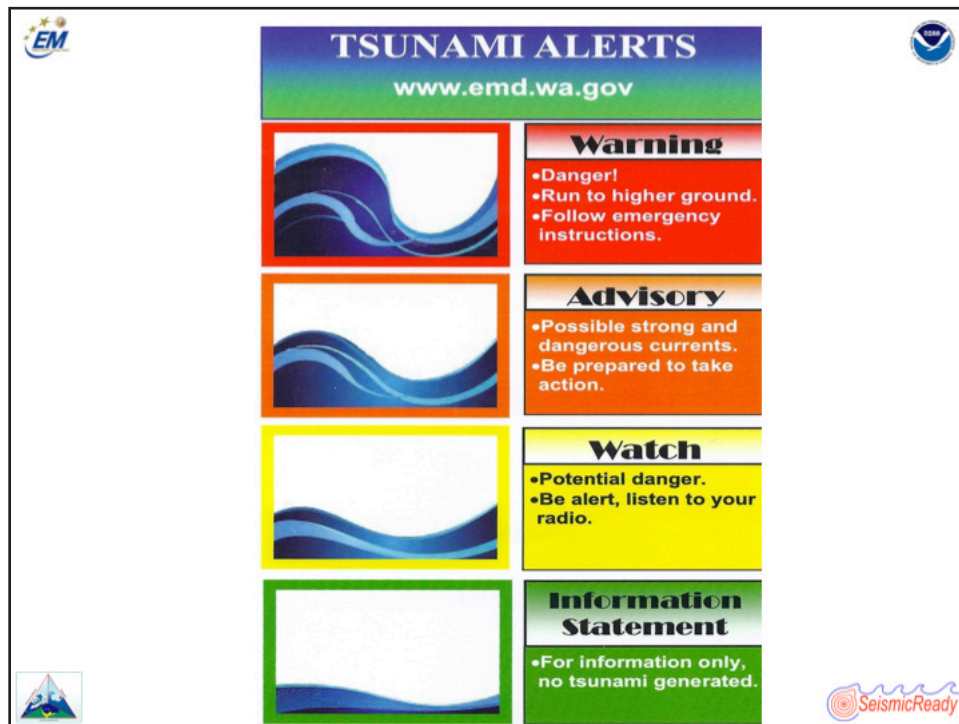
**Stress:**

Clallam County response personnel and volunteers will support the evacuation effort, traffic control, and other requirements for response that have been identified in county and city response plans. However, expect to have wide spread communication outages. The public should not call 911 or families or friends unless an emergency exist.

Example public education message:

- Be familiar with local tsunami response plan
- Do not use your phone except for an emergency

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Slide 8. Tsunami Alerts

**Slide Learning Objectives:**

Understand types and hierarchy of tsunami alert messages issued.

**Stress:**

The slide identifies the 4 types of tsunami alerts that can be received by the Alaska Tsunami Warning Center (TWC) and the appropriate actions that need to be taken.

*Tsunami Warning*

A tsunami warning is issued when a potential tsunami with significant widespread inundation is imminent or expected. It alerts the public that widespread, dangerous coastal flooding accompanied by powerful currents is possible and may continue for several hours after arrival of the initial wave. Warnings also alert government officials to take action for the entire tsunami hazard zone. Appropriate actions to be taken may include the evacuation of low-lying coastal areas, and the repositioning of ships to deep waters when there is time to safely do so. Warnings may be updated, adjusted geographically, downgraded, or canceled. To provide the earliest possible alert, initial warnings are normally based only on seismic information.

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Slide 8. Tsunami Alerts

**(continued)**

*Tsunami Advisory*

A tsunami advisory is issued because of a potential tsunami which may produce strong currents or waves dangerous to those in or near the water. Coastal regions historically prone to damage due to strong currents induced by tsunamis are at the greatest risk. The threat may continue for several hours after the arrival of the initial wave, but significant widespread inundation is not expected for areas under an advisory. Appropriate actions to be taken by local officials include closing beaches, evacuating harbors and marinas, and the repositioning of ships to deep waters when there is time to safely do so. Advisories are normally updated to continue the advisory, expand/contract affected areas, upgrade to a warning, or cancel the advisory

*Tsunami Watch*

A tsunami watch is issued to alert government officials and the public of an event which may later impact the watch area. The watch area may be upgraded to a warning or advisory - or canceled - based on updated information and analysis. Watches are normally issued based on seismic information without confirmation that a destructive tsunami is underway. Normally local governments have 2 or more hours to prepare for a tsunami and one would expect to get evacuation orders if warrant by local authorities.

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Tsunami Response



**TSUNAMI ALERTS**  
[www.emd.wa.gov](http://www.emd.wa.gov)

	<b>Warning</b> <ul style="list-style-type: none"><li>•Danger!</li><li>•Run to higher ground.</li><li>•Follow emergency instructions.</li></ul>
	<b>Advisory</b> <ul style="list-style-type: none"><li>•Possible strong and dangerous currents.</li><li>•Be prepared to take action.</li></ul>
	<b>Watch</b> <ul style="list-style-type: none"><li>•Potential danger.</li><li>•Be alert, listen to your radio.</li></ul>
	<b>Information Statement</b> <ul style="list-style-type: none"><li>•For information only, no tsunami generated.</li></ul>



Slide 8. Tsunami Alerts

**(continued)**

*Tsunami Information Statement*

A tsunami information statement is issued to inform government officials and the public that an earthquake has occurred, or that a tsunami warning, watch or advisory has been issued for another region of the ocean. Usually, information statements are issued to indicate (1) there is no threat of a destructive tsunami and to prevent unnecessary evacuations as the earthquake may have been felt in coastal areas or (2) caution about the possibility of destructive local tsunamis. A watch, advisory or warning may be issued for the area, if necessary, after analysis and/or updated information becomes available.







## Cancellation versus All-Clear

### Cancellation Message

- Issued by TWCs
- Cancels warning, watch, and advisory messages
- Means that destructive waves have stopped
- Does NOT mean it is safe to return to Tsunami Hazard Zone



Slide 9.Cancellation versus All-Clear

### Slide Learning Objectives:



Explain difference between Cancellation and All-Clear.

### Stress:

A Cancellation message only cancels previous Tsunami Warnings, Watches and Advisories that have been issued by the Tsunami Warning Center. It is issued when the tsunami warning center judges that destructive tsunami waves have stopped arriving in areas of Clallam County. It does not mean it is safe for the public to go back into the Tsunami Hazard Zone. Local authorities will let the public know when it is safe to return to the Tsunami Hazard Zone.

### Example public education message:



- Cancellation Message means destructive tsunami waves have stopped.
- Stay out of the Tsunami Hazard Zone until you hear an "All-Clear" Message.



## Cancellation versus All-Clear

**All-Clear**

- Issued by local authority
- Issued when it is **SAFE** to re-enter the Tsunami Hazard Zone



Slide 10.Cancellation versus All-Clear

**Slide Learning Objectives:**

Understand when an All-Clear message is issued.

**Stress:**

Even though the tsunami threat no longer exists, HAZMAT, fires, down utility lines, unsafe buildings, and other public safety issues may still exist that emergency response personnel are responding too. The local authority will issue an All-Clear once it is safe for the public to re-enter the tsunami hazard zone.

Example public education message:

1. Listen for All-Clear Message
2. Return to the Tsunami Hazard Zone

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Tsunami Response





## Key Official Warning Communication Systems in Clallam County Communities

- Emergency Alert System: Radio, Television, and NOAA Weather Radio
- All Hazard Alert Broadcasting (AHAB) Radio





Slide 11. Key Official Warning Communication Systems

**Slide Learning Objectives:**

Understand Clallam County's warning communication systems.

**Stress:**

The Emergency Alert System (EAS) is a national public warning system that uses TV and radio broadcasters, cable television systems, and other communication providers to transmit emergency information. The system also can be used by Washington Emergency Management and Clallam County authorities to deliver important emergency information, such as tsunami evacuation and other critical tsunami information to a targeted area along the coast.

Communities can use the NOAA Weather Radio as an effective all-hazard alert and notification system. Inexpensive weather radio receivers, some cheaper than a pair of shoes, can warn listeners about a hazard before the mass media and local alert systems can do so, giving people additional time to react before danger hits their area. Review of the June 14, 2005 West Coast Tsunami Warning identified that many residents in tsunami inundation zones who received the tsunami warning over the NOAA Weather Radio or Emergency Alert System broadcast self-evacuated prior to civil authority direction. Because tsunamis can attack shores quickly, every minute counts and communities should have a goal to have NOAA Weather Radios become as common as smoke detectors in homes and businesses as these will help to save lives from natural and technological hazards. To emphasize the importance of owning a NOAA Weather Radio, many jurisdictions have designated a Weather Radio Awareness Month and work with retailers to advertise and sell receivers at a reduced price.

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## Key Official Warning Communication Systems in Clallam County Communities

- Emergency Alert System: Radio, Television, and NOAA Weather Radio
- All Hazard Alert Broadcasting (AHAB) Radio





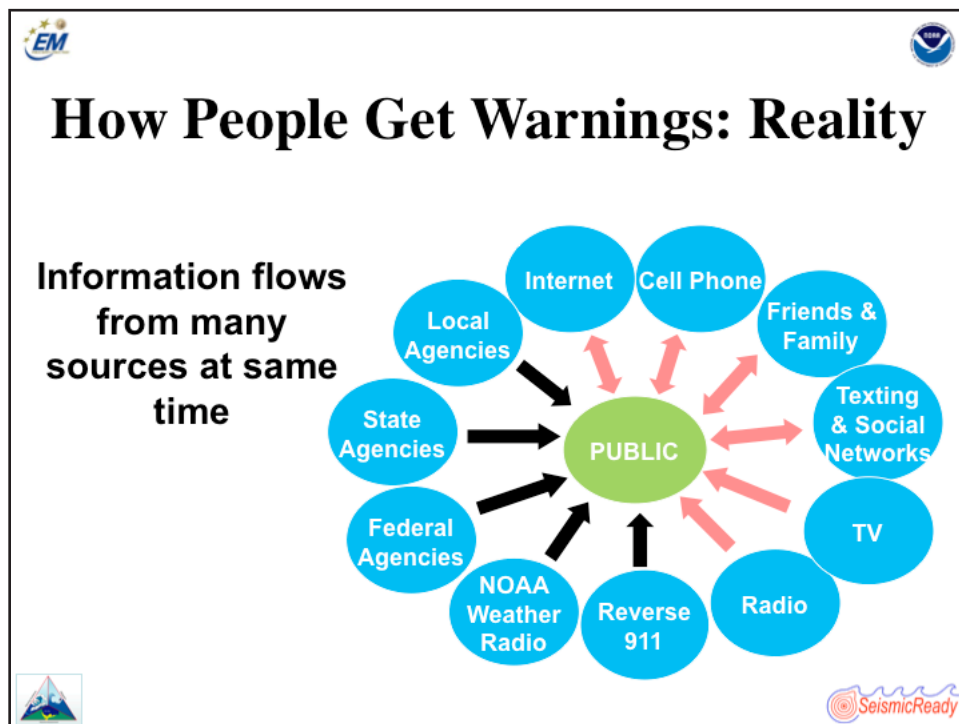
Slide 11. Key Official Warning Communication Systems

**(continued)**

Clallam County use sirens as a way to alert the public to a tsunami strike. In 2000, Washington State developed a partnership with Federal Signal Corporation to develop a tone/voice system. The All Hazard Alert Broadcasting (AHAB) Radio provides a tone to alert the public, and a voice message instructing them on specific action to take. It uses satellite to monitor system health on a 24x7 basis and to activate the system, while also retaining the option for the state, county, local jurisdiction to activate from its emergency operations centers or remotely using handheld equipment. Clallam County AHAB Radio testing is done the first Monday of the month at noon. It is set up for the county to activate on odd months and the Washington Emergency Management Division's Alert and Warning Center on even months.

Example public education message:

- Know the warning systems for your community
- Have a NOAA Weather Radio for your home or business
- Know Sirens are for outdoor use only
- Know what your siren sounds like and/or verbal message delivered



Slide 12. How People Get Warnings

**Slide Learning Objectives:**



Understand the reality of warning dissemination to the public.

**Stress:**

Today, the "last mile" on the coast receives warnings from many different sources. Some are official and many are unofficial. Emergency personnel must actively work to minimize confusion when unofficial information is wrong or misleading. The need to convey consistent information from all stakeholders can best be managed through education and outreach efforts. Emergency management agencies and emergency operation centers utilize Public Information Officers to correctly convey the message information and to correct inconsistent information as soon as it occurs.

Example public education message: Know official sources of tsunami information.







## How to Improve Tsunami Response

Pre-event public education/outreach workshops, town meetings, focus groups, etc...

- Know tsunami natural cues
- Have evacuation maps
- Know evacuation routes/evacuation assembly areas
- Know community support network
- Have family plan and preparedness kit
- Know response for local and distant tsunamis
- Know community warning system



Slide 13. Personal Preparedness Actions

### Slide Learning Objectives:

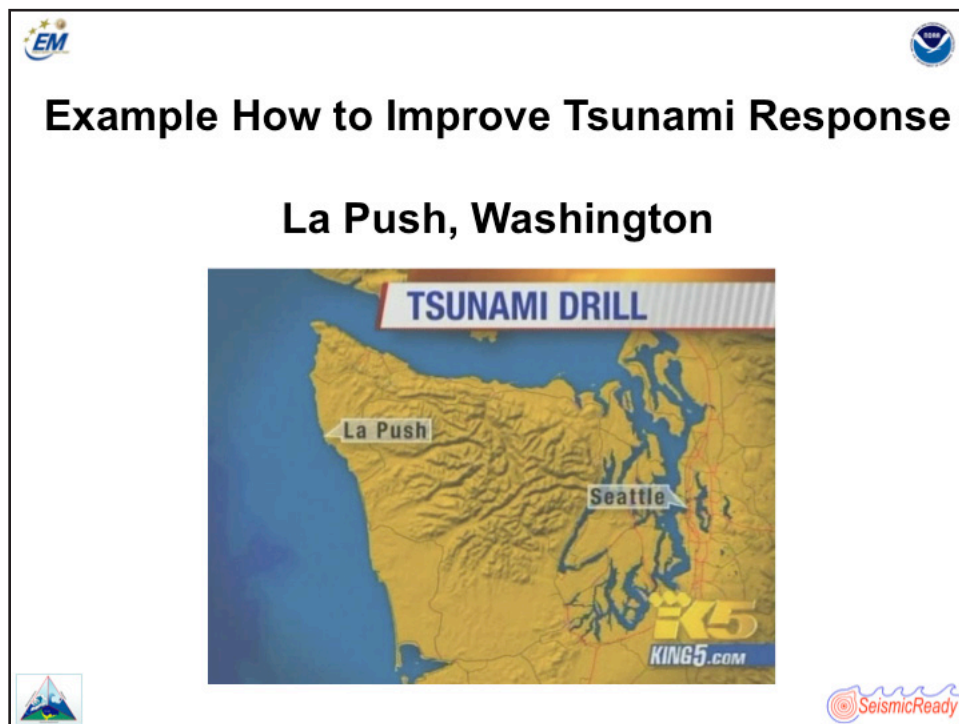
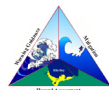
Identify basics the public must understand to improve tsunami response.

### Stress:

A local earthquake event has potential to cause damage to the built environment leaving the public and government officials to deal with destruction of the earthquake and a potential destructive tsunami within tens of minutes after the earthquake. Depending on the time of the event, there could be minimal response personnel available to deal with the response. The public will need to be prepared to response to the event on their own and take immediate action to move to high ground.

Knowledge and preparedness gained through pre-event education can save lives. It is critical that pre-event public education is consistent and community based. Take the time to explain each one of the above items. They are all action messages -- if they understand the above, individuals make correct decisions, and act quickly. We must make tsunami knowledge and preparedness commonplace and ingrained into local culture.

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Tsunami Response



Slide 14. Example of How to Improve Tsunami Response

**Slide Learning Objectives:**

Explain existing example of a community's improvement in response and preparedness.

**Stress:**

La Push, Washington is home to the Quileute Indian Tribe. The majority of its critical infrastructure and its residents live in the tsunami hazard zone. The community has embraced tsunami preparedness and was the first community in the United States to hold evacuation drills. The public, private sector and response agencies take part in an evacuation drill that starts from the notification and ends in the evacuation assembly area. Response personnel use this opportunity to practice procedures and to time how long it takes to safely move the community to high ground. At the evacuation assembly area, the tribal chair, emergency management and response agencies hold a town hall meeting to discuss the evacuation and ask the community to provide feedback on how it went and what they could do to increase their efficiency. Local, state, and national media are invited to participate in the drill and this increases public education and outreach. The video was done by King 5 New, Seattle, Washington, and aired statewide.

Source: Video - Washington Emergency Management Division and King 5 Television, Seattle, Washington

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[www.emd.wa.gov](http://www.emd.wa.gov)  
Washington State  
Emergency Management

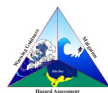


Slide 15. Questions

**Slide Learning Objectives:**

Review learning points from presentation.

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Notes



Notes

***End of Section***

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Community Workshops





Slide 1.

**Slide Learning Objective:**

Introduce the topic.

**Stress:**

Understanding Clallam County's tsunami risk is a critical part of being able to conduct tsunami public education. However, an equally important part is being able to facilitate an effective workshop.





# Outline

## Customized Education

- Why and How to customize

## Challenges

- On-site
- Sustainable



Slide 2. Outline

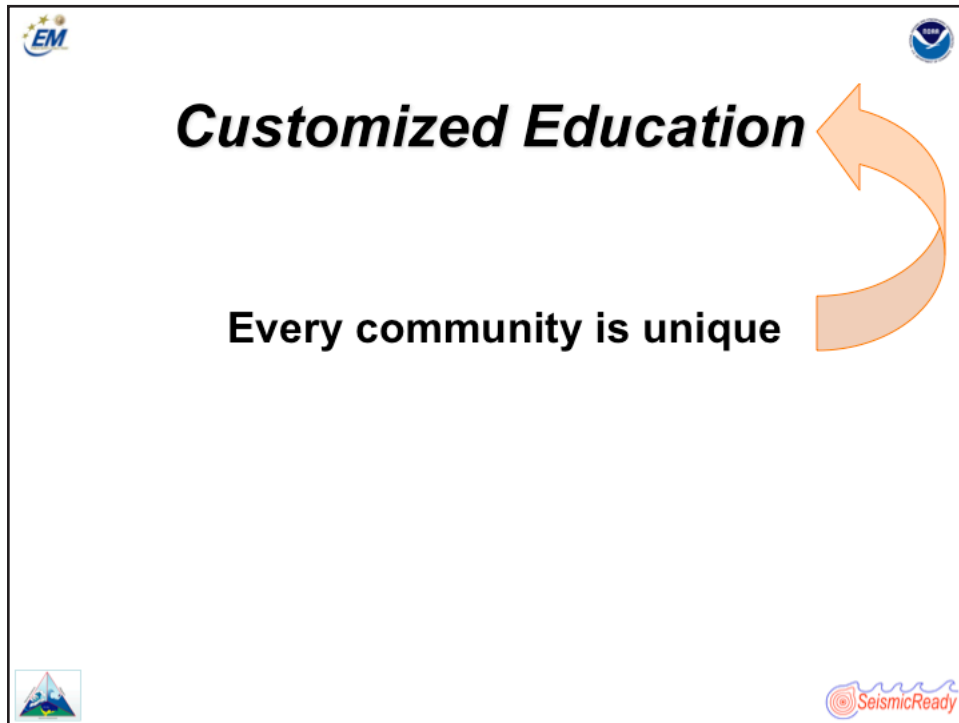
**Slide Learning Objectives:**

Understand the presentation's outline.

**Stress:**

This briefing discusses why and now to customize public education workshops in Clallam County. We will also discuss challenges that you will have on-site and the need to have a sustainable public education program. Participants will have an opportunity to discuss their experiences as well.

Clallam County  
***Train-the-Trainer***  
Community Workshops



Slide 3. Customized Education

**Slide Learning Objectives:**



Understand that every community has unique characteristics.

**Stress:**

Educate the community based on their level of knowledge and preparedness. Remember what you learned about how to identify risk in communities and used the tools and methods provided. Failure to understand specific needs of your audience will reduce your ability to effectively educate them and give them the level of knowledge they need to take the appropriate preparedness actions both prior and during an event.



It is important to remember that even if you customized education, the message should be consistent. For instance, use the slides and notes provided in the train-the-trainer program and materials developed and used by Clallam County Emergency Management. An inconsistent message can cause confusion and individuals taking the wrong actions during response to a tsunami.





## Customizing Education

- **Identify community**
- **Define the purpose of the program and planning process**
- **Define audience**
- **Define participants and their roles**
- **Designate time and location**
  - Avoid marginalizing
- **Conduct Evaluation**



Slide 4. Customizing Education

### Slide Learning Objectives:

Identify important steps towards customizing education.

### Stress:



Workshop purpose will determine what aspects of tsunami's need focus. For example, if purpose is to educate children then warning system product knowledge is not necessary. However, if you are educating K-12 teachers it is important for them to know the different methods of getting warning (ie NOAA weather radio's, from who and type of products etc).

The level of knowledge an audience has determines how much they know and what new information needs to be introduced. For instance, a city planner may know about using zoning ordinances to mitigate against tsunamis but may not know what areas are at-risk in the community they plan for.

Decide what type of experts you need to participate in the workshop. Scientists, first responders, etc. may add credibility to your talk, but may not be necessary depending on the audience and purpose of the program. Clallam County Emergency Management is an excellent source of knowledge and information and should be consulted.



Allow time for discussion by participants. Talking about personal preparedness efforts can influence the actions of participants.





## Customizing Education

- **Identify community**
- **Define the purpose of the program and planning process**
- **Define audience**
- **Define participants and their roles**
- **Designate time and location**
  - **Avoid marginalizing**
- **Conduct Evaluation**

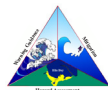



Slide 4. Customizing Education

**(continued)**


Remember (1) time of day and (2) day of week can influence what type of participants you get. For instance, a Monday at 6pm would require some parents to find daycare in order to attend meeting. How can you minimize marginalizing certain groups of people?

How are you going to measure the effectiveness of your meeting/workshop? A questionnaire, survey, pre- and post-test? Depending on the type of education program, a formal test may be appropriate or a simple survey. Such mechanisms will improve your future workshops, making sure you cover the topics most important to your audience. The key is to make the evaluation simple to measure.







## How to Customize Education



**Ask the community**

***Engage community leaders prior to workshop to understand their needs***



Slide 5. How to Customize Education


**Slide Learning Objectives:**

Understand the importance of community engagement.


**Stress:**

Before developing a community-specific workshop, engage community leaders in the development process. Perceived needs and actual needs may be different. Present community leaders with a set of topics that you feel are important, then ask for leaders for their input. Leaders can help determine which topics need more or less emphasis, in their particular community.







## How to Customize Education



**Focus areas:**

- ✓ *Past tsunami events and the impacts on the community*
- ✓ *Cultural/local knowledge of tsunamis and current level of use/understanding*
- ✓ *Current state of TWS and warning communication systems in the community*
- ✓ *Past and current tsunami education programs and outcomes*
- ✓ *What to do and where to go in tsunami event*



Slide 6. How to Customize Education

### Slide Learning Objectives:

Identify recommended tsunami topics to be presented at a community workshop.

### Stress:

The focus areas (in slide and described in detail below) provide a blueprint for your educational program.


When was the last time a tsunami impacted your community? How did it impact your community? How is it anticipated that the next tsunami will impact your community (e.g. what is the exposure and social vulnerability in the inundation zone)? Using photo evidence (e.g. tsunami deposits) helps make a tsunami a reality. For communities with no tsunami experience use survivor stories and photos of impacted communities. It will help them identify with their risk and vulnerability.

Are there indigenous/local stories that can help educate your audience? Local knowledge can provide a powerful link to emphasize existing scientific knowledge.

Understand how that community receives warning information? More specifically, how does your audience receive warning information?


Investigate what programs exist in the community before the workshop. Ask first responders, state/county/local emergency managers, and community leaders. You can help promote existing programs while not duplicating efforts (Target audience specific needs of tsunami education and preparedness).





## On-site

- **Utilize easily understood terms**
- **Engage participants**
- **Cite appropriate educational resources**
- **Positive approach, don't scare audience**



Slide 7. On-site

### **Slide Learning Objectives:**

Understand the basic approaches in a workshop environment.

### **Stress:**


Be prepared to use terms that the general public can understand. Terms like "bathymetry", "topography", "inundation", etc are not always easily understood. Depending on the audience be prepared to use less technical and more descriptive terms.

Engaging participants will keep them interested, but also make them think about their communities strengths and vulnerabilities.


When presenting scientific data, have citations ready and, if possible, visible. This adds credibility to your program and provides additional resources for participants. Also, remember to provide information regarding existing educational resources. Your workshop should not be the last tsunami educational experience for a participant. Tsunami expertise is constantly evolving, your participants should have a resources to further pursue their continuing tsunami education.

Tsunamis can be a frightening prospect, take a positive approach. People shouldn't feel helpless. A lot can be done to minimize loss of life and property. If an individual feels they can reduce their loss that will translate into preparedness and appropriate response during a tsunami event.



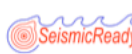



## Sustainability



***Remember...***

**Long intervals between tsunamis, so education must be *constant, consistent and accurate.***



Slide 8. Sustainability

**Slide Learning Objectives:**

- Understand the need to use your State and County resources for consistency.
- Understand that there is never too much education, repetition is critical for infrequent tsunami events.

**Stress:**

Utilize multiple methods to provide information to the public. Preparedness efforts are more likely if public receives the same information from many sources.


Example of different public education platforms:

*YouTube* and other social media are effective ways to reach certain members of the community.


For example, *TsunamiTeacher USA* is a short video explaining tsunami basics.

*YouTube* link: [http://www.youtube.com/watch?v=tUN\\_UTY0GNo](http://www.youtube.com/watch?v=tUN_UTY0GNo)

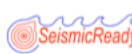





## Challenges



**What are some challenges *you* have encountered in tsunami education/awareness workshops?**

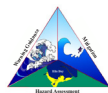


**Slide 9. Challenges**

**Slide Learning Objectives:**

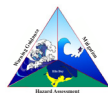
Discuss and share experiences and/or concerns in conducting community workshops.

Clallam County  
***Train-the-Trainer***  
Notes



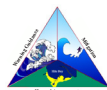
Notes

***End of Section***



## ***Clallam County Tsunami Fact Sheets***

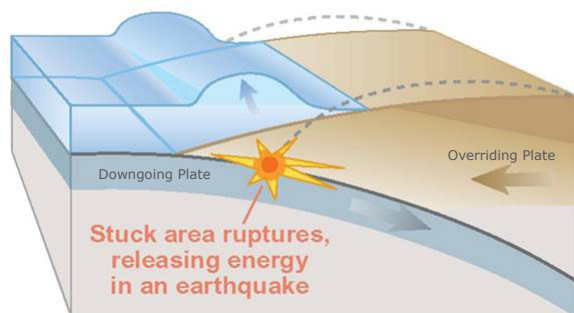
# Local Tsunamis



## Tsunamis from Earthquakes

Earthquakes are the sudden release of stored energy that normally occurs along a fault. Washington State is located at a boundary between two tectonic plates of the Earth's crust. The Juan de Fuca plate descends beneath North America, this process is known as subduction.

*Earthquake starts tsunami*



Accumulated energy raises the seafloor (and the water above it) and a tsunami can be created.

The State is vulnerable to earthquakes originating from three sources:

### 1. Within the downgoing plate.

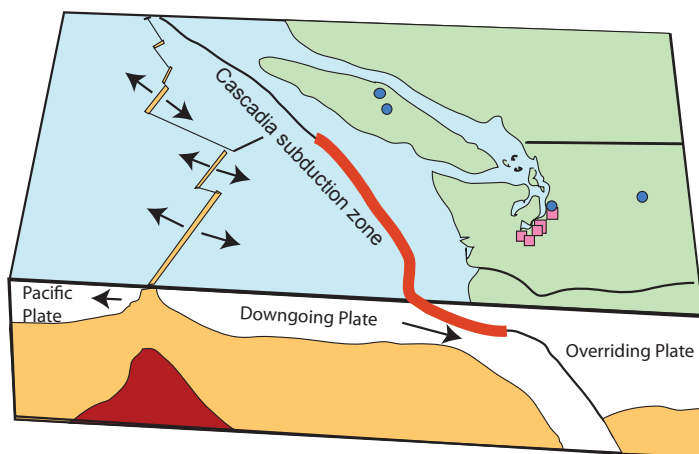
For instance, 3 days after the 1949 Olympia earthquake a landslide generated a tsunami in the Tacoma Narrows. (See photo bottom right).

### 2. At the boundary between plates

(Subduction Zone Earthquake). The 1700 Cascadia Subduction Zone Earthquake caused coastal subsidence and generated a tsunami that impacted our coast.

**3. Within the overriding plate.** A Seattle Fault Earthquake between 900 and 930 A.D. raised shores of central Puget Sound by 20 feet between the Duwamish River and Bremerton and generated a tsunami in Puget Sound.

## Western Washington's earthquake sources



Earthquake Source	Maximum Size	Typical Recurrence Intervals	Examples mapped above
Downgoing plate	7	Decades	1939, 1946, 1949, 1965, 2001
Overriding plate	7	Centuries or millennia	900, 1872, 1918, 1946
Plate Boundary	9	Centuries	1700

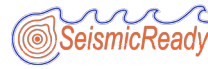
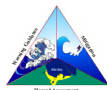
## Tsunamis from Landslides

Landslides pose a local tsunami threat because they can displace waters of Puget Sound and of the state's lakes, reservoirs, and rivers. Landslides probably set off tsunamis as they dropped forests to the floors of Lakes Washington and Sammamish in AD 900-930. The sliding of a steep bluff into Tacoma Narrows (see photo below) generated a wave 8 feet high near Point Defiance in 1949. A rockfall into the Columbia River generated a wave that killed a person near Cathlamet in 1965. Many landslides have made waves in the reservoir behind Grand Coulee Dam, most recently in 2009.

Deltas at the mouths of the Skagit, Snohomish, Duwamish, Puyallup, Nisqually, and Skokomish Rivers probably pose Puget Sound's greatest landslide-tsunami threats. Among the 106 deaths from tsunamis generated during the 1964 Alaska earthquake, 79 resulted from failures of Alaskan deltas that have much in common with deltas of Puget Sound.



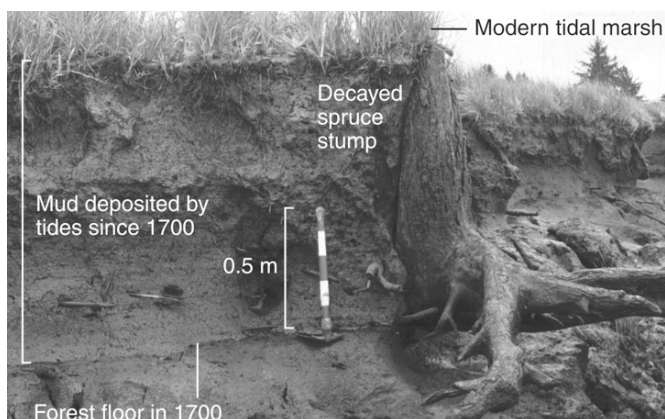
# Tsunami Clues



## Tsunamis deposits

Many times there are no written records or they are insufficient to accurately assess the tsunami hazard. Tsunami deposits allow geologists to expand the record of tsunamis, improving hazard assessment.

Water from a tsunami can deposit sand, cobbles, boulders and debris from offshore beaches over coastal lowlands. These deposits can be preserved in the geologic record giving evidence of past tsunamis to help assess the tsunami hazard for a community. For example, it is possible to determine frequency, magnitude, tsunami flow direction, and run-up and minimum inundation may be estimated by the inland extent and elevation of tsunami deposits.



The above image is what we find on our coast. This is from the Naselle river which flows into Willapa Bay. You can see the decayed spruce stump, the old forest floor in 1700, and the thick sequence of mud deposited since 1700.

## Historical tsunami databases

Internet databases allow communities to access historical tsunami records. These records aid in understanding the tsunami hazard and risk in a coastal community. Also, these online resources may help communities identify the source of a tsunami occurrence identified in written or oral histories. Online tsunami data bases include:

Novosibirsk Tsunami Laboratory  
National Geophysical Data Center

## Oral history and written records

Oral and written records compliment modern science and technology in identifying hazardous events. Along with modern scientific tsunami numerical modeling, oral and written records provide information for communities to determine their level of risk. Local knowledge can also supplement scientific data and help educate the population about impending hazards. Consequently, lives may be saved by oral history and written records.

Tribal knowledge has valuable information that is passed down to the next generation in the tradition of mythology. Oral traditions of Native American tribes of the Washington Coast describe what is interpreted as a huge earthquake and tsunami destroying coastal villages.

The story describes the Thunderbird as a kind mystical being. The bird soared over the coastal waters and seized the Whale. A struggle ensued first in the water. "The waters receded and rose again. Many canoes came down in trees and were destroyed and numerous lives were lost."



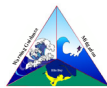
Oral history from the Makah Tribe tells of an earthquake in the middle of the night. Elders tell the young to run for high ground. Those who listen to their warning survive. In the morning they find their village, and all neighboring coastal villages washed away and no survivors. This oral history was also noted in the diary of James Swan on January 12, 1864.

These oral histories helped identify the source of the January 1700 "Orphan Tsunami" which swept across the Pacific causing destruction along the Pacific coast of Japan.

Corroboration with accurate written records from Japanese samurai, merchants, and villagers allows confident knowledge of the size and time of this great earthquake.



# Distant Tsunamis



## Probable sources

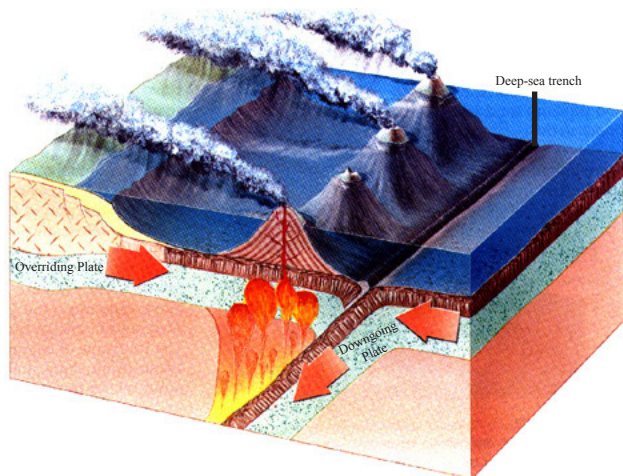
Subduction zones are largely located along the volcanic mountain chains that make up the "Ring of Fire". They can generate tsunamis that sweep through the entire Pacific basin causing a tsunami risk to Washington coastal communities.

### Active Volcanoes, Plate Tectonics, and the "Ring of Fire"



## Subduction

Subduction occurs when one plate slides under another plate that usually gets locked together. When the overriding plate breaks free it causes an earthquake.



Upon release the seafloor (and the water above it) is raised, a tsunami is created.

## Impact on Washington

While distant tsunamis have caused significant damage, deaths and injuries in Oregon and California, only one significant tsunami struck Washington's Pacific coast in recent history. The 1964 Alaska earthquake generated a tsunami that resulted in debris deposits throughout the region, minor damage in Ilwaco, damage to two bridges on State Highway 109, a house and smaller buildings being lifted off their foundations in Pacific Beach, and piling damaged at the Moore cannery near Ilwaco.

The 1964 tsunami also was recorded inland in the Strait of Juan de Fuca (Friday Harbor), Puget Sound (Seattle), and the Columbia River (Vancouver). However, recent tsunami modeling indicates that Washington has not yet experienced its worst case distant tsunami event.

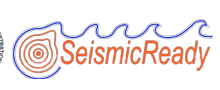


Highway 109 bridge over Copalis River collapsed and trailers and cars were damaged during the 1964 Alaskan Tsunami.

## Frequency in Washington

Due to the various tsunami sources on the "Ring of Fire", distant source tsunamis are more frequent than local source tsunamis. Historical records (to 1854) and geologic investigations indicate that tsunamis have struck Washington's shores numerous times. While only one tsunami has caused major damage, strong currents accompanying a tsunami threaten the maritime industry as well as individuals in and around the water. For example, a 1960 earthquake along the coast of Chile generated a tsunami causing non-destructive inundation at Grays Harbor, Tokeland, Ilwaco, Neah Bay, and Friday Harbor.

# Tsunami Hazard Zone



## What is the Tsunami Hazard Zone?

A populated and at-risk area determined to have the likeliest probability of being flooded by tsunamis.

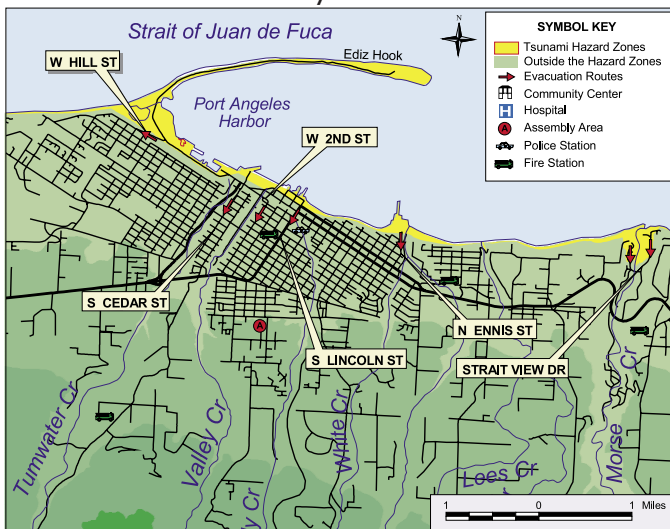
## What is needed to determine the Tsunami Hazard Zone?

Components include:

- Inundation map
- Community input
- Geologic evidence
- Local infrastructure
- Oral history

## What is an inundation map?

An inundation map displays the areas likeliest to be flooded by a tsunamis.



Example Evacuation Map:  
Port Angeles, Washington.

**Inundation Area in Yellow**

## How is the inundation area determined?

Tsunami models simulate tsunami generation, propagation of waves to the impact zone and inundation into a community. Inundation studies can be conducted taking a probabilistic approach or a particular "worst case scenario". The results include information about the maximum wave height, maximum current speed and maximum inundation line. Also waves' heights accompanied by arrival times at different locations can be determined.

## Inundation Map uses

### Awareness initiatives

Examples: Personal preparedness, pollutant anchoring/removal.

### Evacuation Planning

Examples: Evacuation routes, assembly areas and evacuation signs.

### Land Use

Examples: Open space or low- density zoning.

### Designing structures

Examples: Elevated structures.

### Isolation identification

Examples: Vertical evacuation plans.

Note: Vertical evacuation should be pursued where vehicular evacuation is unlikely and high ground can not be reached prior to tsunami wave arrival.

## Tsunami hazard zones and inundation maps are not permanent

Once an inundation line is drawn, the line is not permanent. New techniques for tsunami modeling are always improving the capacity to create more effective inundation maps. Also, difficult to detect land changes can effect tsunami inundation mapping. Consequently, inundation maps should be used for guidance in planning not as definitive and permanent maps

## Why is inundation mapping and modeling important?

Evacuation maps, routes and assembly areas can be identified once inundation modeling and mapping is developed.

Special needs populations should determine evacuation assembly areas or vertical evacuation refuge sites. Special needs populations must be able to reach safe sites within the expected wave arrival time for safe evacuation.

Tsunami Evacuation Map Brochures should be developed for visiting, or tourist populations. Tsunami evacuation routes should be adequately marked with signage. Official tsunami signage creates pre-event awareness and improves life safety.

# Tsunami Risk Reduction



## What is risk?

Existing definitions include:

Risk = Hazard \* Exposure

Risk =  $\frac{(\text{Vulnerability} * \text{Hazard})}{\text{Capability}}$

## Why understand your risk?

Identifying and understanding a community's risk allows appropriate time and effort and effective use of resources for reducing that risk. A community needs to identify assets with high vulnerability and low capability to recover from a tsunami and start appropriate preparedness and response activities.

## Hazard & vulnerability

By understanding a community's hazard exposure, physical vulnerability, and social vulnerability, evacuation planning, public education, and other preparedness and response programs can be developed. For instance:

- **Exposure.** Assets and resources in the tsunami hazard zone. (People, businesses, cultural and natural resources, roads, bridges, utilities)
- **Sensitivity.** Asset characteristics and implications of a tsunami. (What conditions will complicate evacuation?)
- **Resilience.** Ability to manage risk, adapt during crises and recover from tsunami. (How prepared is the community to respond? How will individuals receive and react to warnings?)



Map of Clallam County communities with land in the tsunami-inundation zone. (2008)

## Increasing capability through preparedness

At-risk populations in the community have their own perceptions of risk. Social science suggests people are more inclined to act on hazard education information when they believe present actions can mitigate future losses (Paton et al., 2008). Therefore, public education must not focus on uncontrollable (and infrequent) tsunami hazards. Instead, focus should be on individual actions that can reduce the impacts of typical tsunamis. A good example of this is our tsunami brochures that identify evacuation routes and assembly areas, natural warning signs, official warning protocols and steps to take to prepare for a tsunami event.

- What should I do if an earthquake occurs while at the coast?
1. Drop, cover and hold. Get under a sturdy object and hold on. Watch for falling objects.
  2. As soon as the shaking is over, move to high ground or inland. Do not wait for an official warning.
  3. Stay away from the coast. Waves may continue to arrive for hours.
  4. Listen to your local radio station for an official "All Clear" notice before returning to the coastal area.
  5. Be alert for aftershocks.

- What can I do to protect myself from a tsunami?
- Develop a family disaster plan. Everyone needs to know what to do on their own to protect themselves from an earthquake.
  - Be familiar with local Emergency Management earthquake and tsunami plans. Know where to go to survive a tsunami.
  - Be prepared to survive on your own for a minimum of three days.
  - Prepare a disaster supply kit for your home, automobile and work. A list of recommended supplies for your kit appears on the inside of this brochure.
  - Take a first aid course and learn survival skills. Knowledge is your greatest defense against potential disaster.

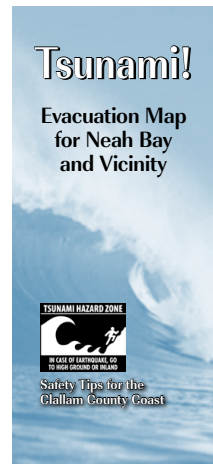
### CONTACTS

Washington Military Department  
Emergency Management Division  
Phone: (800) 562-6188  
Web: [www.wemd.wa.gov](http://www.wemd.wa.gov)  
Mailing address:  
Washington Military Department  
Emergency Management Division  
Camp Murray  
Washington 98430-3122

For information regarding emergency and disaster preparedness for the Makah Nation, please contact:

Makah Tribal Council  
Phone: (360) 645-2201  
Fax: (360) 645-2788  
Email: [makah@tribalcouncil.net](mailto:makah@tribalcouncil.net)  
Web: [www.makah.com](http://www.makah.com)  
Mailing address:  
Makah Tribal Council  
PO Box 115  
Neah Bay, WA 98557

June 2007  
Printed on Recycled Paper



Community-specific tsunami brochures provide valuable life-saving information. *Example from Neah Bay.*

## Evacuation plans reduce risk

When planning and developing tsunami evacuation routes, we must identify special population groups lacking the ability to anticipate, cope with, resist and recover from the impacts of a tsunami.

Those that are in need of help to evacuate, should talk to neighbors and community support groups to pre-arrange evacuation to high ground. Remember that special populations in the community will require additional time to arrive to an evacuation assembly area. It is recommended that they time how long it takes them to get to an assembly area, and compare to expected wave arrival time.

During a local-source event, evacuation on foot may be your only option. Debris from the earthquake and flooding may increase the time it takes to get to high ground.

# Tsunami Response



## Tsunami arrival times vary

Washington coastal communities need to be prepared for either a local tsunami such as the one generated by the Cascadia Subduction Zone in 1700 striking the coast within minutes of the earthquake; or, a distant tsunami that allows several hours of warning before the tsunami reaches our coastline, such as the 1964 Alaskan event.

## Local tsunami response

A local earthquake event has potential to cause damage to the built environment leaving the public and government officials to deal with destruction of the earthquake and a potential destructive tsunami within tens of minutes after the earthquake. The public need to understand the natural warning signs of an impending tsunami and be prepared to respond to the event on their own by taking immediate action to move to high ground.

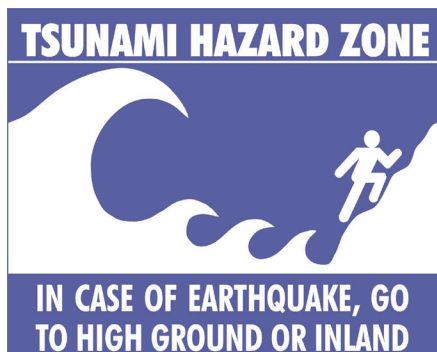
### Natural Warning Signs:

**Strong coastal earthquake**  
**Rapid sea level changes**  
**Roaring sound**

## Self-evacuation

Steps public can take to manage a self-evacuation:

- Develop a family plan.
- Identify the nearest assembly areas and evacuation routes. Walk the routes.
- Prepare disaster supply kit. Food, water, etc. may not be available for an extended period of time at the assembly areas.



## Distant tsunami response

Distant tsunamis give the federal, state, and local/tribal governments time to assess the tsunami risk and make evacuation decisions. The tsunami warning center in Alaska provides information to decision makers that implement evacuation plans. A tsunami warning and evacuation order will be disseminated over community communication systems. Response personnel and volunteers support the evacuation effort of the tsunami hazard zone.

Examples of key official warning communication systems in Washington's communities

- Emergency Alert System: Radio, Television and NOAA Weather Radio
- All Hazard Alert Broadcasting (AHAB) Radio

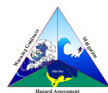


AHAB Radios (*left*) are placed throughout Washington in at-risk communities. NOAA Weather Radios (*right*) should be placed in homes, schools, and businesses to provide critical information to everyone.

## How to improve tsunami response

Community-based education helps the public respond correctly to local or distant tsunamis. Pre-event public education, workshops, town hall meetings, focus groups and other outreach efforts need to be consistent and continuous.

- Important public outreach messages include:
- Recognize natural warning signs for a local event
- Identify communication systems in the community that provide tsunami alert messages
- Obtain an evacuation map
- Get to know evacuation routes and evacuation assembly areas. Walk the routes to know how long it takes to get to the assembly area
- Develop a community support network
- Develop a family plan and preparedness kit
- Understand how local government will respond to a tsunami event



## ***Clallam County Tsunami Resources***

# Clallam County

## ***Train-the-Trainer***

### Resources



#### General

##### *Websites for State/County/Tribal Emergency Management*

- State: <http://www.emd.wa.gov>
- Clallam County: <http://www.clallam.net/>
- Lower Elwha Klallam Tribe: <http://elwha.org/>
- Quileute Indian Tribe: <http://quileutenation.org/>
- Makah Nation: <http://www.makah.com/>

##### *Other*

- UNESCO/IOC ITIC, Tsunami Glossary 2008, Intergovernmental Oceanographic Commission, Paris, UNESCO. IOC Technical Series, 85, 2008.  
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Cascadia Subduction Zone Earthquakes: A magnitude 9.0 earthquake scenario, CREW, 2005.  
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Gonzalez, F. I. Tsunami!, Scientific American, 280(5), 56-65, 1999.  
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Gonzalez, F.I., B.L. Sherrod, B.F. Atwater, A.P. Frankel, S.P. Palmer, M.L. Holmes, R.E. Karlin, B.E. Jaffe, V.V. Titov, H.O. Mofjeld, and A.J. Venturato (2003): Puget Sound Tsunami Sources - 2002 Workshop Report. A contribution to the Inundation Mapping Project of the U.S. National Tsunami Hazard Mitigation Program, NOAA OAR Special Report, NOAA/OAR/PMEL, 34 pp.  
[http://nctr.pmel.noaa.gov/puget\\_workshop.html](http://nctr.pmel.noaa.gov/puget_workshop.html)

# Clallam County

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### **Resources**



#### **Tsunami Hazard and Tools (continued)**

##### *Hazard Mitigation plans that are on the web*

- WA State Hazard Mitigation Program – Tsunamis  
[http://www.emd.wa.gov/plans/documents/ehmp\\_5.8\\_tsunami.pdf](http://www.emd.wa.gov/plans/documents/ehmp_5.8_tsunami.pdf)
- Clallam County Hazard Mitigation Plan  
<http://www.clallam.net/EmergencyManagement/documents/ClallamHazardMitigation-FINAL10252010.pdf>

Jansa, A., Monserrat, S., and Gomis, D.: The rissaga of 15 June 2006 in Ciutadella (Menorca), a meteorological tsunami, *Adv. Geosci.*, 12, 1–4, 2007.  
<http://www.adv-geosci.net/12/1/2007/>

National Geophysical Data Center Historical Tsunami Database  
<http://www.ngdc.noaa.gov/hazard/tsu.shtml>

NOAA Center for Tsunami Research.  
<http://nctr.pmel.noaa.gov/>

NOAA Tsunami – The Tsunami Story.  
<http://www.tsunami.noaa.gov/tsunami>

Thunderbird and Whale Stories  
[http://www.pnsn.org/HIST\\_CAT/STORIES/legend.html](http://www.pnsn.org/HIST_CAT/STORIES/legend.html)

Tsunami Evacuation Brochures and Maps for Clallam County and Coastal Tribes  
<http://www.dnr.wa.gov/ResearchScience/Topics/GeologyPublicationsLibrary/Pages/tsuevac.aspx>

T-3 Factsheets. (Located in this Guidebook).

Understanding Local and Distant and Tsunamis (Video).  
[http://www.emd.wa.gov/hazards/haz\\_video\\_tsunami\\_types.shtml](http://www.emd.wa.gov/hazards/haz_video_tsunami_types.shtml)

UNESCO/IOC ITIC, Tsunami, The Great Waves, Revised Edition, Intergovernmental Oceanographic Commission, Paris, UNESCO, 16 pp., illus. IOC Brochure 2008-1, 2008,  
[http://ioc3.unesco.org/itic/files/great\\_waves\\_en\\_2006\\_small.pdf](http://ioc3.unesco.org/itic/files/great_waves_en_2006_small.pdf)

Usapdin, T.P., A. Soemantri, and V. Agustin, The story that saved the lives of the people of Simeuleu, Indonesia, December 19, 2005.  
<http://www.ifrc.org/docs/News/05/05121901/index.asp>

Washington Tsunami Inundation Maps  
[http://www.dnr.wa.gov/Publications/ger\\_tsunami\\_inundation\\_maps.pdf](http://www.dnr.wa.gov/Publications/ger_tsunami_inundation_maps.pdf)



### **Tsunami Hazard and Tools (continued)**

Washington Tsunami Modeling of Cascadia Modeling Tsunami Inundation from a Cascadia Subduction Zone Earthquake for Long Beach and Ocean Shores, NOAA Technical Memorandum OAR PMEL-137.

<http://www.pmel.noaa.gov/pubs/PDF/vent2949/vent2949.pdf><http://www.pmel.noaa.gov/pubs/PDF/vent2949/vent2949.pdf>

### **Risk, Preparedness and Response**

All Hazards Alert Broadcast (AHAB) Information (Video)

[http://www.emd.wa.gov/hazards/haz\\_video\\_tsunami\\_warnings.shtml](http://www.emd.wa.gov/hazards/haz_video_tsunami_warnings.shtml)

Atwater, B. F. et al. Surviving a tsunami—lessons from Chile, Hawaii, and Japan. U.S. Geol. Surv. Circ., 1187 (1999, revised 2005, 2009).

[http://ioc3.unesco.org/itic/files/USGSCircular\\_1187\\_rev2009\\_standard.pdf](http://ioc3.unesco.org/itic/files/USGSCircular_1187_rev2009_standard.pdf)

Community Emergency Response Teams (CERT)

<https://www.citizencorps.gov/cert/>

DHS Tsunami Awareness Course (AWR217)

<http://ndptc.hawaii.edu/sites/default/files/TsunamiCourseDescriptionAWR-217.pdf>

Disaster Response Guidebook- For Hotels and Motels on Washington's Coast (PDF)

<http://www.emd.wa.gov/hazards/documents/HotelMotelBook.pdf>

Emergency Resource Guide (PDF)

[http://www.emd.wa.gov/publications/pubed/emergency\\_resources\\_guide.pdf](http://www.emd.wa.gov/publications/pubed/emergency_resources_guide.pdf)

FEMA P646A, Vertical Evacuation from Tsunamis: A Guide for Community Officials.

<http://www.fema.gov/library/viewRecord.do?id=3808>

Home Preparedness

[http://www.emd.wa.gov/preparedness/prep\\_home.shtml](http://www.emd.wa.gov/preparedness/prep_home.shtml)

How the Smart Family Survived a Tsunami (PDF)

[http://www.emd.wa.gov/publications/pubed/how\\_the\\_smarts\\_survived\\_tsunami\\_book.pdf](http://www.emd.wa.gov/publications/pubed/how_the_smarts_survived_tsunami_book.pdf)

Map Your Neighborhood

<http://www.emd.wa.gov/myn/index.shtml>

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**Risk, Preparedness and Response (continued)**

Media Tsunami Volcano Guidebook (PDF)

<http://www.emd.wa.gov/hazards/documents/MediaTsunamiVolcanoGuidebook.pdf>

National Tsunami Hazard Mitigation Program

<http://nthmp.tsunami.gov/>

NOAA Weather Radio

<http://www.nws.noaa.gov/nwr/>

[http://www.emd.wa.gov/publications/pubed/noaa\\_weather\\_radio.shtml](http://www.emd.wa.gov/publications/pubed/noaa_weather_radio.shtml)

Paton, D., Houghton, B. F., Gregg, C. E., Gill, D. A., Ritchie, L. A., McIvor, D., Larin, P., Meinhold, S., Horan, J., & Johnston, D.M. (2008) "Managing tsunami risk in coastal communities: Identifying predictors of preparedness," The Australian Journal of Emergency Management, 23(1): 4-9.

[http://www.ema.gov.au/www/emaweb/rwpattach.nsf/VAP/\(084A3429FD57AC0744737F8EA134BACB\)%7EAJEM\\_Feb08\\_paton.pdf/\\$file/AJEM\\_Feb08\\_paton.pdf](http://www.ema.gov.au/www/emaweb/rwpattach.nsf/VAP/(084A3429FD57AC0744737F8EA134BACB)%7EAJEM_Feb08_paton.pdf/$file/AJEM_Feb08_paton.pdf)

Pet Preparedness

[http://www.emd.wa.gov/preparedness/prep\\_pets.shtml](http://www.emd.wa.gov/preparedness/prep_pets.shtml)

Preparing Your Emergency Evacuation Kit (Video)

[http://www.emd.wa.gov/hazards/haz\\_video\\_emergency\\_kit.shtml](http://www.emd.wa.gov/hazards/haz_video_emergency_kit.shtml)

Preparing Your Evacuation Routes (Video)

[http://www.emd.wa.gov/hazards/haz\\_video\\_evacuation\\_routes.shtml](http://www.emd.wa.gov/hazards/haz_video_evacuation_routes.shtml)

Tsunami Preparedness Along the West Coast (USGS) (Video)

<http://www.youtube.com/watch?v=9E7NAmEjiVE>

TsunamiReady Program

<http://www.tsunamiready.noaa.gov/>

Tsunami Survival Game for Kids

<http://www.emd.wa.gov/preparedness/videos/TsunamiGame.swf>

TsunamiTeacher USA: Tsunami Basics (Video)

[http://youtu.be/tUN\\_UTY0GNo](http://youtu.be/tUN_UTY0GNo)

*Download:* [http://itic.ioc-unesco.org/index.php?option=com\\_content&view=article&id=1711&Itemid=2000&lang=en](http://itic.ioc-unesco.org/index.php?option=com_content&view=article&id=1711&Itemid=2000&lang=en)

Washington Emergency Management Division (2004): Run to High Ground! -Audience Level: K-6 grade; Washington Military Department, Video 14minutes (Located in folder)

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**Resources**



**Risk, Preparedness and Response (continued)**

Washington Emergency Management Division (1999a): Surviving great waves of destruction; Tsunami curriculum Grades 7-12. Washington Military Department, 52 pp.  
Washington Emergency Management Division (1999b): Tsunami curriculum Grades K-6. Washington Military Department, 68 p.  
[http://ioc3.unesco.org/itic/categories.php?category\\_no=158](http://ioc3.unesco.org/itic/categories.php?category_no=158)

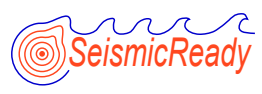
Wood, Nathan, and Soulard, Christopher, 2008, "Variations in community exposure and sensitivity to tsunami hazards on the open-ocean and Strait of Juan de Fuca coasts of Washington," U.S. Geological Survey Scientific Investigation Report 2008-5004, 34p.  
<http://pubs.usgs.gov/sir/2008/5004/>

UNESCO/IOC, TsunamiTeacher, IOC Manuals and Guides, 47, 2006 (DVD and online)  
<http://ioc3.unesco.org/TsunamiTeacher/>

Understanding Tsunami Warnings (Video)  
[http://www.emd.wa.gov/hazards/haz\\_video\\_tsunami\\_warnings.shtml](http://www.emd.wa.gov/hazards/haz_video_tsunami_warnings.shtml)

U.S. West Coast / Alaska Tsunami Warning Center, User's Guide for the Tsunami Warning System in the West Coast/Alaska Tsunami Warning Center Area-of-Responsibility, WC/ATWC, 43 pp, 2009  
<http://wcatwc.arh.noaa.gov>

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**Notes**



Notes

***Thank You***

**For more information, contact:**

Dave Nelson: 253-512-7075 or [d.nelson@emd.wa.gov](mailto:d.nelson@emd.wa.gov)